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ABSTRACT

This document contains technology-based learning activities for the Illinois energy utilization technology course at the orientation level (grades 9 and 10). This packet includes a course rationale, course mission statement, course description, course outline, suggested learning objectives for each of the energy utilization areas, and suggested learning experiences. The packet also contains developed learning activities. The content can be presented through short lectures, discussion, media, demonstrations, or hands-on activities. The course units can either follow a 9- or an 18-week format. There are five units in this course: (1) introduction to energy utilization technology; (2) energy conversion and transmission systems; (3) fossil fuels and energy conservation; (4) solar energy; and (5) using alternate energy sources. Each unit may contain suggested learning objectives and suggested learning activities. Each activity within a unit contains some or all of the following components: introduction, materials and supplies list; activity procedures, activity analysis, various kinds of drawings and other graphics, teaching aids, and student handouts. (NLA)

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ED347309

Illinois Plan for Industrial Technology Education

Energy Utilization Technology Curriculum Materials

Illinois State Board of Education

Department of Adult, Vocational and Technical Education

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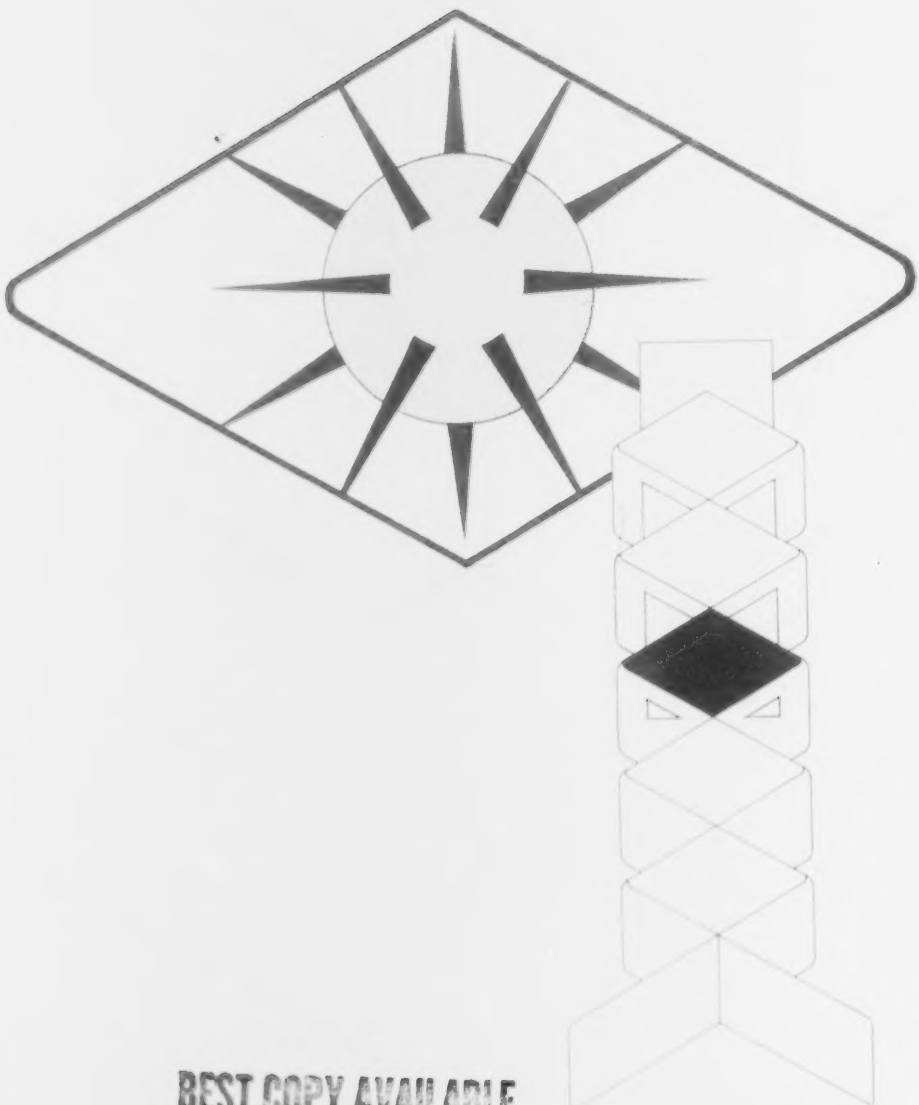

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Illinois Plan for Industrial Technology Education

Energy Utilization Technology Curriculum Materials FY 91

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USING THIS PACKET

This packet contains technology-based learning activities for the Energy Utilization Technology course at the orientation-level (grades 9 and 10) of the Illinois Plan for Industrial Technology Education curriculum project. These materials supplement the 1989 Illinois Plan Orientation Curriculum Guide and were developed to complement hands-on workshops.

The materials were designed to enable teachers attending the hands-on workshops to implement the activities at their home school. Workshop participants are encouraged to use the materials as a model for future curriculum development.

The Energy Utilization Technology Activity Packet includes a course rationale, course mission, course description, course outline, suggested learning objectives for each of the energy utilization areas, and suggested learning experiences.* The packet also contains developed learning activities, many of which have been collected from earlier activity packets developed by the project and past issues of **Technology News Today** (TNT). The packet also contains several newly developed activities like fluid power trainer, passive solar energy, active solar energy, energy conservation, energy conversion, wind energy, geothermal energy, and hydroelectric energy.

When implementing these activities, it is important to teach the resources, technical processes, industrial applications, and technical impact for each technology education topic. By including content from each of these areas, students are ensured a complete orientation. Content should also address integrated skills like transition skills, generalizable skills, and vocational ethic skills, as well as the State Goals for Learning. The content can be presented through short lectures, discussion, media, or demonstrations. However, most of the time should be spent on hands-on learning activities.

The following abbreviations are used in this document:

TA = Teaching Aid
SH = Student Handout
DR = Drawing

Acknowledgment

The development of these materials were made possible through a grant from the Illinois State Board of Education, Department of Adult Vocational and Technical Education, Research and Development section.

* Information taken from the 1989 Illinois Plan Orientation Curriculum Guide.

ENERGY UTILIZATION TECHNOLOGY

Course Rationale

Since the oil embargo in the early 70's, energy has become a major concern to our nation. Over the past two decades our society has dealt with gas shortages, numerous conservation programs, unstable fuel prices, depleting world finite resources, and an increase demand for energy. We live in a society that is dependent on various modes of transportation, automated production processes, sophisticated communication systems, and time-saving devices, all of which use energy. As our society becomes more energy conscious, the move toward alternative energy sources and conservation techniques has become more apparent.

The demand for more energy has created a need to educate citizens about the reality of the energy situation. In doing so, persons who become involved in learning about traditional fossil fuels, conservation techniques, and alternative energy sources can develop a better understanding of the uses and impacts of energy on society and the environment.

It will be up to today's students to make the decisions on how energy will be utilized in the future. It is education's responsibility to provide students the knowledge to make rational and informed decisions concerning energy. A course in Energy Utilization Technology can provide a student with an education background and the understanding needed to become an informed citizen.

Course Mission

The purpose of the Energy Utilization Technology course is to orient students to the basic resources, technical processes, industrial applications, and technological impacts related to energy conversion and transmission, fossil fuels, energy conservation, solar power, and alternative energy systems. The course will help students to:

- use and understand the verbal and symbolic language used to describe energy systems and phenomenon;
- develop and present creative solutions to present and future energy problems;
- identify and investigate potential career opportunities in the area of energy;
- understand the evolution of energy technology and its influence on our culture, and;
- safely use common tools, materials and processes to design, build, and test energy systems.

Course Description

The Energy Utilization Technology course includes units on energy conversion and transmission, fossil fuels and energy conservation, solar power, and alternative energy systems. Each unit will involve students in a wide range of activities and experiences. Student learning experiences will include things like testing mechanical, electrical, and fluid power systems; conducting an energy audit; building solar collectors; and constructing a wind generator.

Course Outline

In the spirit of orientation, students should be introduced to a wide range of fossil fuels, conservation techniques, and alternative energy technologies. The following course outline lists the recommended units for either a nine or an eighteen week format. Potential lesson topics are provided under each unit title. Each lesson should embrace as many of the unit objectives as possible. In a nine week format, an emphasis should be placed on the terminology, resources, processes, applications, impacts, careers and safety concepts that relate to the lesson topic.

Sample Energy Utilization Technology Course Outline

I. Introduction to Energy Utilization Technology

II. Energy Conversion and Transmission
- A. Energy conversion
- B. Mechanical systems
- C. Electrical systems
- D. Fluid Power systems

III. Fossil Fuels and Energy Conversion
- A. Using fossil fuels to generate electricity
- B. Conducting energy audits
- C. Implementing energy conservation strategies

IV. Solar
- A. Passive solar (e.g., direct and indirect gain)
- B. Active solar (e.g., hydraulic and pneumatic)
- C. Photovoltaic
- D. Solar farms
- E. Solar central receivers

V. Alternative Energy Systems
- A. Wind
- B. Geothermal
- C. Biomass
- D. Hydroelectric (i.e., tide, wave, river current, ocean current)
- E. Nuclear

Adapting the Energy Utilization Technology Course Outline to Nine or Eighteen Week Formats

Hands-on learning activities are one of the most powerful ways of helping students learn about technology. Unfortunately, they are very time-consuming. The following strategies can be employed to use available laboratory time more efficiently without sacrificing important unit objectives:

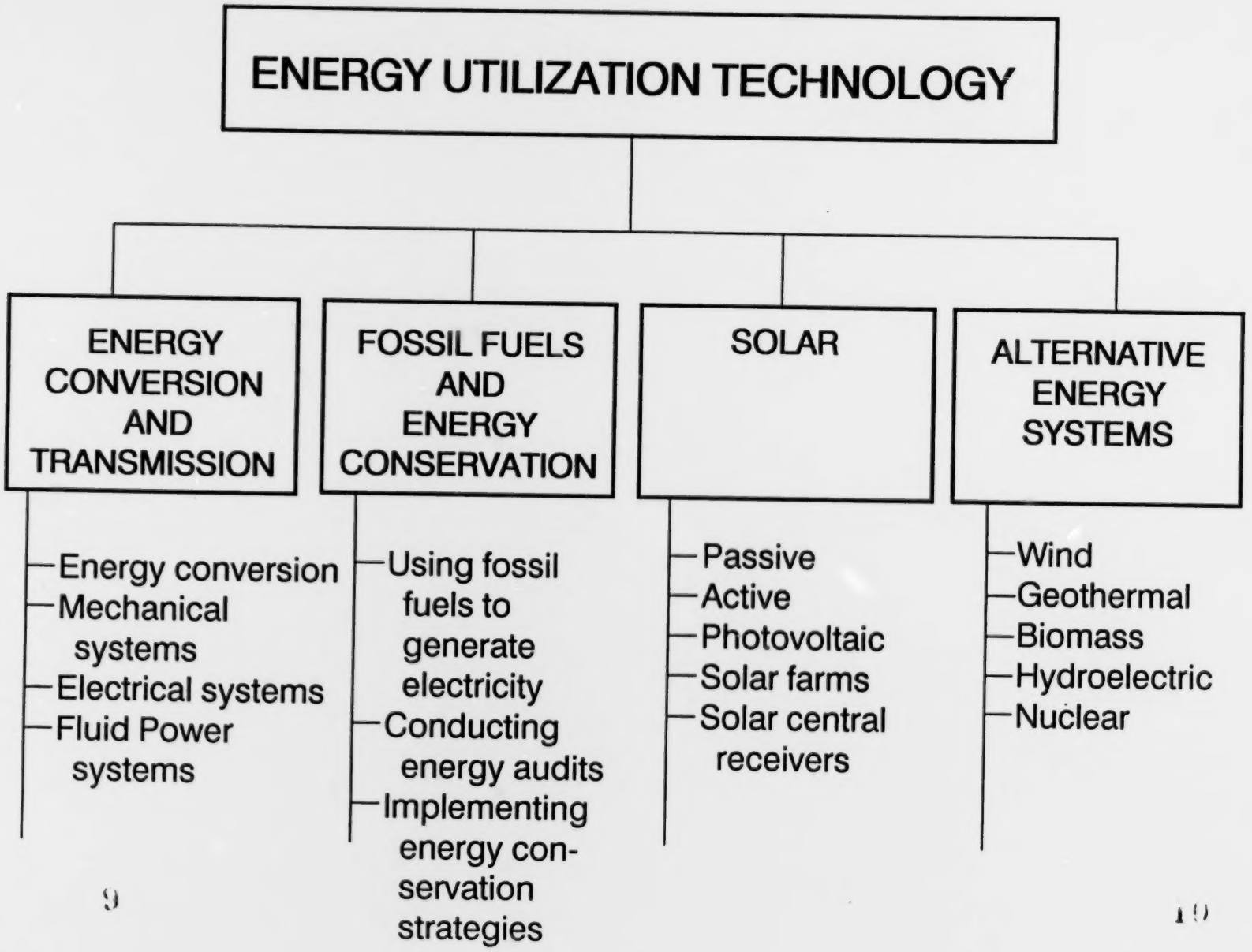
- Divide the class into small groups and assign each group a different learning activity related to the lesson topic. When each group has finished their assigned activities, have students present their experiences to the rest of the class. For example, during the alternative energy unit, have each group develop and present an alternative energy system.

- Avoid assigning complex laboratory activities when simpler activities will enable students to experience important concepts and achieve the desired objectives. For example, during the solar energy unit, have students design, build, and test solar collectors out of shoe boxes instead of industrial grade materials.

- Prepare work stations that organize the tools and materials needed to conduct laboratory activities prior to class. For example, during the energy conversion and transmission unit, develop kits for electrical or fluid power circuits that students will build and test.

- Have students experience a wide range of concepts through one or two robust learning activities. For example, during the solar unit, have students make a solar energy system (i.e., collection, conversion, storage, distribution, and control) transfer to passive, active, photovoltaic, solar central receiver, and solar farm systems.

During an eighteen week format, students can engage in more complex learning activities and experience given topics in greater depth. In addition, there is an opportunity to provide a wider range of learning experiences. The study of technology allows for an infinite number of learning experiences. Therefore, it is important to select and implement learning activities in an efficient manner.


ENERGY UTILIZATION TECHNOLOGY
ENERGY CONVERSION AND TRANSMISSION
FOSSIL FUELS AND ENERGY CONSERVATION
SOLAR
ALTERNATIVE ENERGY SYSTEMS
Energy conversion
Mechanical systems
Electrical systems
Fluid Power systems
Using fossil fuels to generate electricity
Conducting energy audits
Implementing energy conservation strategies
Passive
Active
Photovoltaic
Solar farms
Solar central receivers
Wind
Geothermal
Biomass
Hydroelectric
Nuclear

INTRODUCTION
TO
ENERGY UTILIZATION
TECHNOLOGY

INTRODUCTION TO ENERGY UTILIZATION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the introduction to Energy Utilization Technology unit, students will be able to:

A. Define and properly use common energy terminology like potential energy, kinetic energy, renewable, and entropy. SC1

B. Categorize energy resources as chemical, thermal, electrical, nuclear, or radiant forms of energy. SC1

C. Categorize energy resources like solar, geothermal, petroleum, and biomass as renewable, nonrenewable, and inexhaustible energy resources. SC1

D. Identify the three basic types of fossil fuels (i.e., coal, petroleum, natural gas). SC1

E. Identify examples of alternate energy resources including wind, hydroelectric, and solar energy. SC1

F. Describe how the basic laws of nature like the law of conservation of matter, the first law of thermodynamics (conservation of energy), the second law of thermodynamics (energy degradation) and Newton's laws of motion govern the utilization energy. SC1

G. Identify basic transportation, residential, commercial, and industrial applications for fossil fuel and alternate energy resources. SC1

H. Describe how supply and demand affect the cost and utilization of fossil fuel and alternate energy resources.

I. Define and distinguish between potential and kinetic forms of energy. SC1

J. Measure phenomena like force, work, heat, energy, power, pressure and torque using appropriate measuring tools and units. SC4

K. Forecast the consequence of being dependent on nonrenewable resources and develop scenarios describing the role of energy conservation and alternate energy in reducing our dependence on fossil fuels. SC2

Suggested Learning Activities

1. Introduce students to a variety of fossil fuels and alternative energy resources. Include topics like geothermal, hydroelectric, coal, nuclear, and wind energy. Assign each student a topic and ask them to develop a display describing the energy resource. Each display should identify if the energy resource is a potential or kinetic energy; a renewable, nonrenewable or inexhaustible energy resource, and a mechanical, chemical, thermal, radiant or nuclear form of energy.

2. Explain how to use the tools, techniques, and units used to measure things like force, work, heat, energy, power, pressure and torque. Using tools like spring scales, thermometers, and VOM meters, have students measure things like work performed by a lever, heat produced by a candle in BTU's, and energy used to illuminate a light bulb.

AN OVERVIEW OF ENERGY UTILIZATION TECHNOLOGY

Introduction

As a human being, you are constantly using energy. The room you are in can be heated and the lights can be turned on. That takes energy. Most students come to school in vehicles such as a bus, car or subway. These modes of transportation use energy. You are constantly listening to a stereo or watching TV. They take energy. Where does all of this energy come from? Will it always be there when we need it? The more you know about the source of energy and how to use it wisely, the better off you will be. This unit will help you achieve these two goals.

In the following Technology Education Activity, you will gather information on an energy topic. In doing so, you will be exposed to the main ideas that will be covered throughout the Energy Utilization course.

Materials and Supplies

Provide each student access to:

- Construction paper
- Rubber cement
- Scissors
- Straight edge
- Tape
- Markers
- Stencils
- a variety of energy-related resource materials (e.g., magazines, textbooks, encyclopedias).

NOTE: If available, a computer and a popular graphic software program can be used to enhance the appearance of the displays.

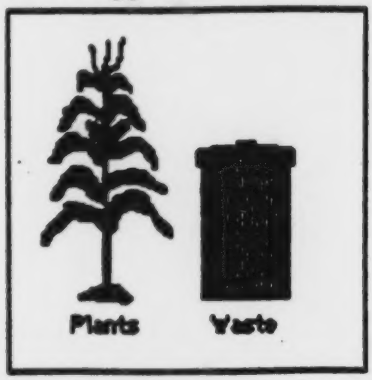
Procedures

1. Obtain an energy topic from your instructor.
2. Collect the information found on your activity worksheets (SH #1). To gather information on your topic, use sources like magazines, textbooks, and encyclopedias.
3. Once the information has been collected, the next step is to complete the "Student Worksheet" (SH #2).
4. Have your work checked by the teacher.
5. Once you receive your teacher's approval, use the information from your data collection sheet to complete the final draft of the Student Worksheet. It is important for you to do it neatly, because it will be shared with everyone in the class.
6. Present your findings to the rest of the class.
7. Turn in your poster design to be evaluated.
8. After worksheets have been evaluated, there are two alternate methods which can be used to share the information with the rest of the class. One method is to create a wall

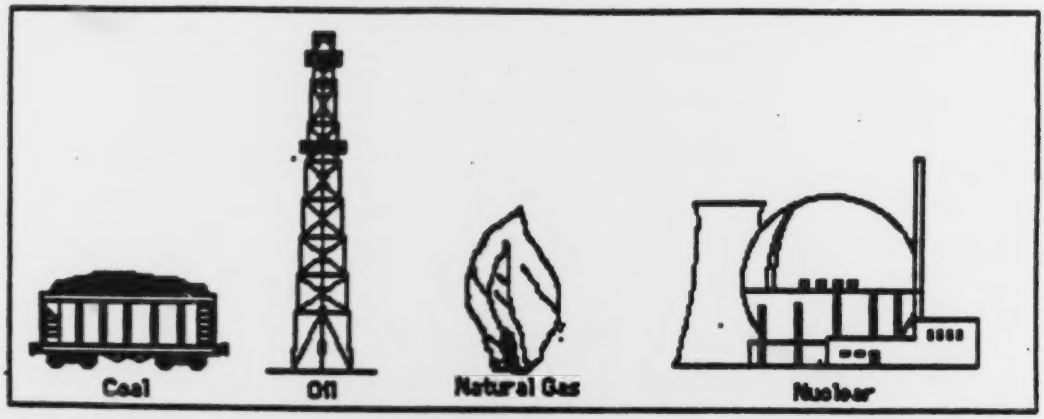
display. At the top of the display place the title "Energy Utilization." After the title, label three headings, "Renewable," "Nonrenewable," and "Inexhaustible." The students can place their poster under the appropriate heading. This would provide a visual reference for the type of energy being studied throughout the rest of the course.

The second method is to develop an energy booklet. The booklet would have a title page called "Energy Utilization." The booklet would be divided into three sections titled "Renewable," "Nonrenewable," and "Inexhaustible." The students' final data sheets should be reproduced and placed in the appropriate section. Once the booklet has been completed, each student should receive a copy. The booklet can be placed in an energy folder that the students refer to throughout the Energy Utilization course.

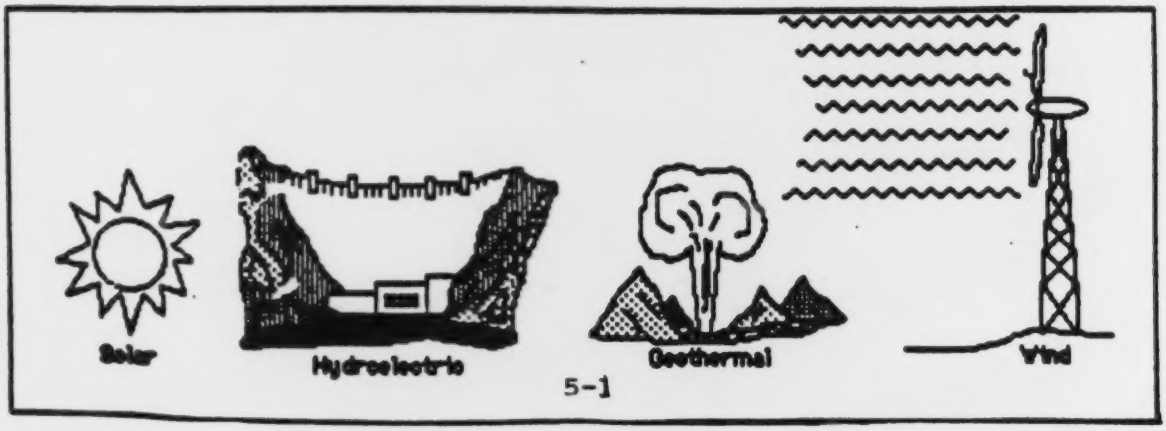
Renewable: Forms of energy that can be replenished if managed properly.



Nonrenewable: Forms of energy with limited supplies that cannot be replaced.



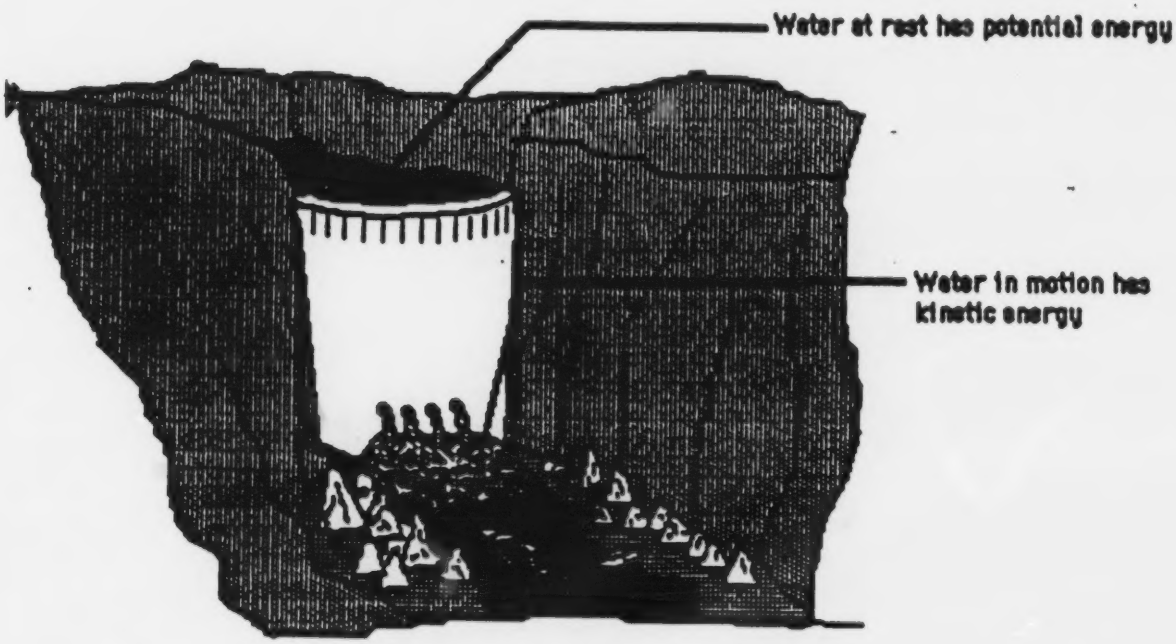
Inexhaustible: Source of energy with an infinite supply that will always be available.



5-1

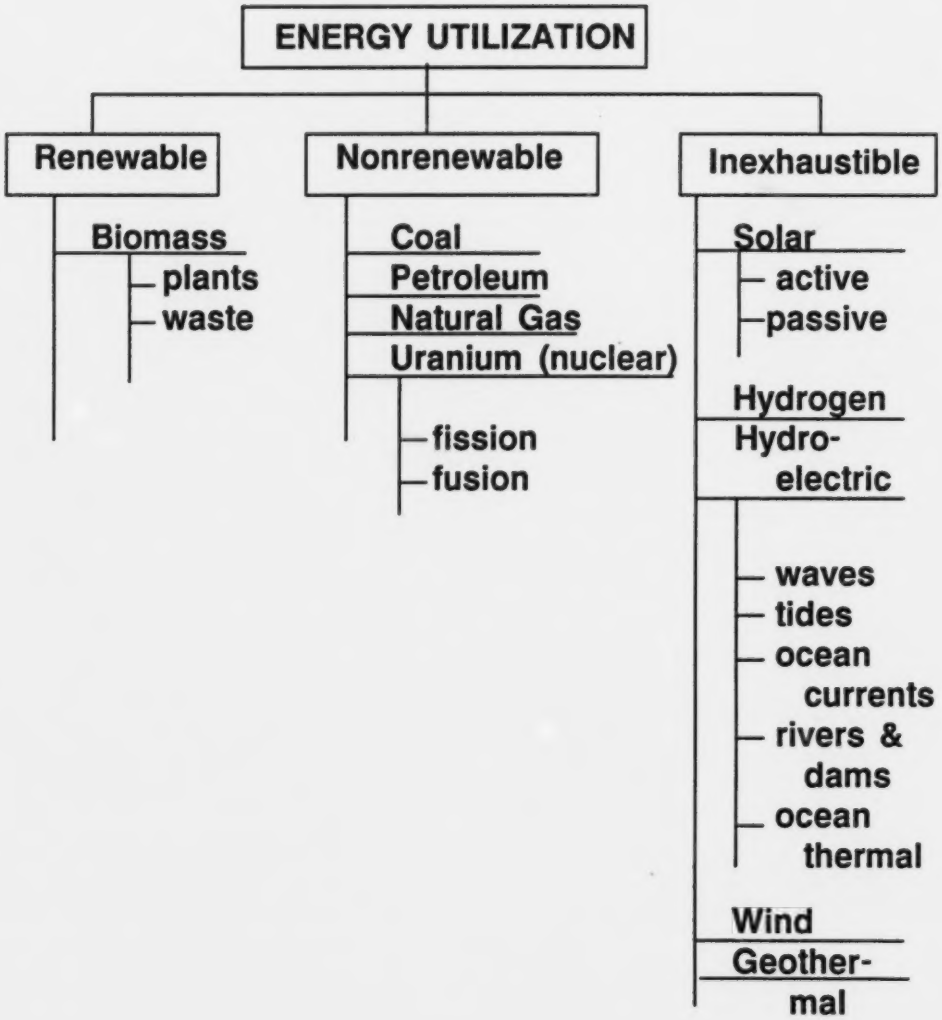
Potential: Stored energy waiting to change or cause movement.

Kinetic: The ability of moving objects to do work



FORMS OF ENERGY

1. Mechanical energy: Energy represented by moving objects.
2. Electrical energy: The movement of electrons, more commonly called electricity.
3. Thermal or heat energy: The energy produced by the movement of molecules.
4. Chemical energy: Stored energy contained within matter because of its chemical composition.
5. Radiant energy: The waves of sunlight that travel from the sun.
6. Nuclear energy: The energy released when the atoms found in matter are spent.


ENERGY UTILIZATION
Renewable
Nonrenewable
Inexhaustible
Biomass
plants
waste
Coal
Petroleum
Natural Gas
Uranium (nuclear)
fission
fusion
Solar
active
passive
Hydrogen
Hydro-electric
waves
tides
ocean currents
rivers & dams
ocean thermal
Wind
Geother-mal

STUDENT ENERGY DATA COLLECTION SHEET

Student's Name _____ Topic Name _____

1. Define or describe your topic.

   Reference Sources

2. Where is your topic found in the United States?

   Reference Sources

3. How is your topic being used?

   Reference Sources

4. Describe if your topic is renewable, nonrenewable, or inexhaustible.

   Reference Sources

5. Describe whether your topic is a potential or kinetic energy source.

   Reference Sources

6. Describe what form your energy topic can be found.

   Reference Sources

STUDENT WORKSHEET

Final Draft

ENERGY LOGO	ENERGY TOPIC DESCRIPTION

1. Categorize your energy topic as renewal, nonrenewable or inexhaustible. Explain.

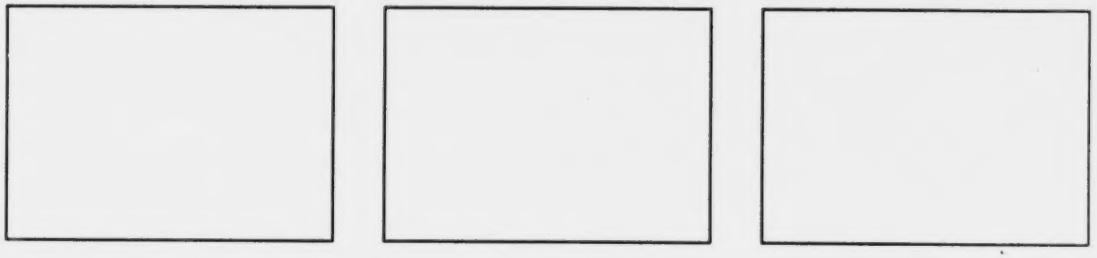
2. Is your energy topic either a potential or kinetic energy source? Explain.

3. In what form of energy can your topic be found? Explain.

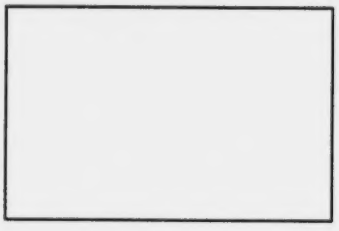
4. How is your topic used and applied in our society?

5. Where can your energy source be found and used in the United States?

6. Use the boxes below to develop three energy logo sketches.



7. From the sketches above, create one refined logo.



Activity Analysis

Directions: Circle the best answer.

1. Wood is an example of a/an _____ energy source.

   A. renewable
   B. nonrenewable
   C. inexhaustible

2. Coal is an example of a/an _____ energy source.

   A. renewable
   B. nonrenewable
   C. inexhaustible

3. Wind is an example of a/an _____ energy source.

   A. renewable
   B. nonrenewable
   C. inexhaustible

4. An example of potential energy is _____.

   A. an apple falling from a tree.
   B. a ball rolling down a hill.
   C. wind.
   D. the sun producing active solar energy.

5. An example of kinetic energy is _____.

   A. a windy day
   B. sunshine
   C. water resting at the top of a dam
   D. water from a dam producing hydroelectric power

6. The energy that is produced by the movement of molecules is:

A. electrical
B. mechanical
C. thermal
D. chemical

7. Energy that is represented by moving objects is:

A. electrical
B. nuclear
C. thermal
D. mechanical

8. The energy that is produced through the waves of sunlight that travel from the sun is:

A. thermal
B. radiant
C. chemical
D. nuclear

9. The energy that is released when the atoms found in matter split:

A. thermal
B. nuclear
C. chemical
D. radiant

10. The energy that is produced through the movement of electrons:

A. thermal
B. mechanical
C. electrical
D. chemical

ENERGY CONVERSION
AND
TRANSMISSION SYSTEMS

ENERGY CONVERSION AND TRANSMISSION SYSTEMS

Suggested Learning Objectives

Upon completion of the Energy Conversion and Transmission unit, students will be able to:

A. Define and properly use common alternate energy **terminology** like transducer, pneumatics, efficiency, thermosiphoning, and mechanical advantage. SC1

B. Identify basic **applications** for energy conversion and transmission systems including providing light, generating electricity, measuring heat, creating motion, and applying forces. SC1

C. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with energy conversion and transmission systems (e.g., conductors, technicians, primary energy resources).

D. Describe basic energy conversion and transmission **processes** like pumping, conducting, regulating, converting, controlling, and grounding.

E. Describe the social and environmental **impacts** associated with energy conversion and transmission including using valuable raw materials, improving efficiency, visual pollution, and energy utilization. SC2

F. Identify and evaluate **career** opportunities associated with energy conversion and transmission (e.g., mechanical engineer, scientist, fluid power technician) based on their interests, talents, and career expectations.

G. Describe the major milestones in the **history** and evolution of energy conversion and transmission technology including the establishment of vacuum as a product of atmospheric pressure by Blaise Pascal, the inventions of the first storage battery by Allesandro Volta, the invention of the light bulb by Thomas Edison, and the discovery of the photovoltaic effect. SS2

H. Identify potential hazards and establish guidelines for **safe** behavior when working with electrical, mechanical, thermal, and fluid power systems. PH3

I. Design, build, and test electrical, mechanical, thermal, and fluid power systems that address an energy conversion or transmission problem. SC4

J. Analyze technological systems and identify their mechanical, electrical, fluid power, and thermal subsystems. SC1

K. Determine the basic energy transducers, control devices, and conductor paths used in simple electrical and fluid power systems.

L. Determine the simple machines used in simple mechanical systems. SC1

M. Determine the heat sources, thermal conductors, insulators, and heat skins used in simple thermal systems. SC1

N. Measure phenomena like force, work, heat, energy, power, pressure and torque using appropriate measuring tools and units. SC4

O. Determine unknown quantities like voltage, pressure, flow rate, or current in an electrical and fluid power system based on two known quantities. SC4

P. Design, build, and test energy systems that convert one form of energy to another (e.g., chemical to electrical, chemical to thermal, electrical to mechanical, linear mechanical to rotary mechanical). SC1

Q. Determine the input and output forms of energy associated with energy conversion devices like batteries, bulbs, motors, generators, thermocouples, and photovoltaics. SC1

R. Select and defend the best energy conversion and transmission system for a given problem based on societal, monetary, environmental, and safety considerations. SC2

S. Forecast the potential effects of innovative energy conversion and transportation technologies on consumer products, industrial processes, and energy utilization. SC2

Suggested Learning Activities

1. Introduce students to the basic forms of energy: chemical, electrical, mechanical, thermal, and radiant. Explain how energy is converted from one form to another. Have students make and/or test energy conversion devices like batteries, photovoltaics, generators, pumps, Hero engines, and thermocouples. Ask students to identify the form of input and output energy for each device. Discuss current and potential applications for each energy conversion device.

2. Compare and contrast how electrical, mechanical, thermal, and fluid power systems are used to perform work. Have students use commercial or constructed trainers to build working electrical, mechanical, thermal, and fluid power systems that perform a given task. Ask students to use appropriate tools to measure things like force, work, heat, energy, power, pressure and/or torque.

3. Introduce students to a variety of energy transducers, control devices, conductor paths, and output transducers used in electrical systems. Using a variety of components, have small groups of students build and test electrical circuits that address assigned problems. Possible problems could include things like activating a motor at a given temperature, sounding an alarm when a magnetic connection is broken, being able to turn on or off a light from two locations, requiring both hands to be in defined locations before a motor will work, and using resistance (photocell) to measure light.

4. Introduce students to the various simple machines used in mechanical systems. Using a variety of commercial or fabricated components like cams, gears, levers, linkages, pulleys, sprockets, chains, and racks, have students build and test mechanical systems that address assigned problems. The problems could be expressed in an industrial context, featuring challenges like converting a linear motion to a rotary motion, converting rotary motion to a linear motion, converting a clockwise motion to a counter-clockwise motion, and enlarging a given motion by a factor of four.

5. Introduce students to the pressure sources, control devices, conductors, and actuators used in hydraulic and pneumatic fluid power systems. Using commercial fluid power components or things like medical syringes, windshield washer pumps, aquarium valves, and plastic hose, have students build and test fluid power systems that address assigned problems. Possible problems could include things like lifting a given object with a cylinder, clamping an object in a fixture, activating a lever with a cylinder, activating several cylinders in a given sequence, and pumping a fluid to several containers at various rates simultaneously.

6. Introduce students to the heat sources, thermal conductors, thermal insulators, and heat sinks used in thermal energy systems. Using a variety of materials like copper tubing, fiberglass insulation, sheet metal, sterno, and electric heat elements, have groups of students design, build and test thermal systems that address assigned problems. Potential problems could include things like heating a container of water, heating air within an enclosure, cooling the air within an enclosure, transmitting heat from one fluid to another, and storing heat in a thermal mass. Ask students to identify the thermal techniques and systems used in their homes.

7. Explain how many technological systems can be more easily understood by breaking them down into their smaller subsystems. Ask students to identify the major mechanical, electrical, fluid power, and thermal systems on an automobile. Have them categorize things like head lamps, the radiator, steering linkage, and water pump as levers, conductors, pressure sources, actuators, output transducers, control devices, etc. Have students use the same techniques to analyze other technological systems like an industrial robot, internal combustion engine, or a milling machine.

8. Introduce students to the various techniques used to transmit energy from one location to another. Provide groups of students problem statements that can be addressed with an electrical, mechanical, thermal, and/or fluid power system. Using commercial and/or fabricated components, have each group design, build, and test a system that addresses their problem. Have students present and defend their solutions based on societal, monetary, environmental, and safety considerations.

9. Discuss career opportunities in energy conversion and transmission systems. Include occupations at the nonskilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to energy conversion and transmission systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

10. Discuss the milestones in the history and evolution of energy conversion and transmission systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

MECHANICAL SYSTEMS

Introduction

Mechanical energy is defined as energy in motion. Examples of energy in nature are running water in a river and wind movement. When people couple these natural means to some human device like a crankshaft, they turn that natural energy into a usable form. The energy that is used to do work is harnessed with the use of mechanical devices. The term, mechanical conversion of energy, refers to changing of energy into a transmission system. Mechanical energy can be used to do work and can also be measured. When people use mechanical energy to perform some type of work, it is referred to as mechanical power.

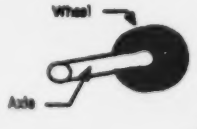
Many times, the mechanical energy must be modified or changed before it can be used to do useful work. Many different devices, referred to as machines, are used. Machines can be very large and complex, but they can also be as simple as a ramp.

When humans used the first tool is hard to document, but it is believed that when they picked up the first object (maybe a rock or stick) and used it to perform a simple form of work, the first tool was born. There are six simple machines that form the base for all machines. These six simple machines are the lever, wheel and axle, pulley, inclined plane, wedge, and the screw. These simple machines are used primarily to gain a mechanical advantage, but may also be used to gain a speed advantage as in the sprocket arrangement of a ten-speed bicycle. The six simple machines can be divided into two basic categories, the principle of the lever and the principle of the inclined plane (see illustration below). From these six simple forms such things as cams, gears, linkages, sprockets, chains and racks can be developed or explained.

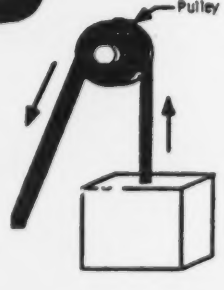
MECHANICAL SYSTEMS
Simple Machines

Lever - a bar that rests on a pivot point.

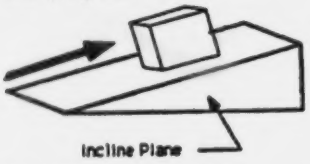
Wheel and Axle - a shaft that is connected to a wheel



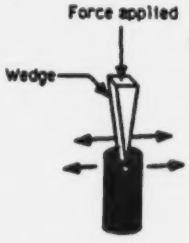
Pulley - a wheel that turns on an axis of rotation



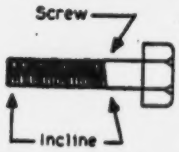
Inclined plane - a sloping surface



Wedge - two inclined planes put together



Screw - an inclined plane put in a spiral around a cone



Many times, mechanical energy can be used without changing it in any way. An example would be a turbine directly tied to a generator or the lawn mower engine that turns the mower blade. Other times, the mechanical energy must be changed in form or direction to do the desired work. One example of this is the rack and pinion steering system in a car. Here, rotary motion is changed to a form of linear motion. This helps the driver turn the car in the desired direction. Sometimes, a clockwise motion must be changed to a counter-clockwise motion. This is done in the pencil sharpener. Gears are meshed together and as one turns in one direction, the other gear will move in the opposite direction. To increase speed of the motion, gear diameters can be changed. The change of speed is done with different gear ratios. This is the ratio of the number of teeth on the drive gear to the number of teeth on the driven gear. An example of changing the drive speed to four times faster could be done in the following manner. A driven gear has 12 teeth and the drive gear has 48 teeth. The ratio is 48:12 or 4:1. This means the driven gear will turn four times faster than the drive gear. If the drive gear (48 tooth gear) is traveling at 10 r.p.m., then the driven gear will turn at 40 r.p.m. This transmission of power produces the proper balance of speed when desired. Many different control devices can be used to change mechanical energy. In today's world, this has been done many different ways and will continue to keep changing as technology expands in the future.

Materials and Supplies

Provide the following:

- Four wheels (3 - 1 1/2" dia. or larger and 1 - 3" dia. or larger)
- Plastic strip (2" x 10"), 1/8" to 3/16" thick
- Axles (3" long), 1/8" diameter
- Assorted construction material (e.g., wood, masonite, metal)
- Strip heater

- String
- Hot glue gun
- Duct tape
- 3 straws
- Rubber bands
- Stop watch
- 20' tape measure
- 1 mouse trap or mouse trap spring
- 1 small drive wheel (size may vary)
- Overhead projector

Problem Statement

The student will construct an example of a vehicle that will demonstrate the converting of linear motion to rotary, clockwise to counter-clockwise motion, and increase the given motion. The vehicle must travel a distance of 15 feet in 10 seconds or less.

Activity Procedures

Divide the students into groups of two or three.

1. Review all the information that was presented by your instructor.
2. With the materials provided, brainstorm possible vehicle solutions.
3. Once complete, transfer your ideas in the form of sketches using graph paper.
4. From the solutions, select the one design your group feels will best solve the problem. Several ideas may be combined to make the best design.
5. Once finished, share your ideas with your instructor.
6. After receiving the instructor's approval, build the test vehicle. NOTE: Be sure to obtain permission from your instructor before using any pieces of power equipment.
7. Upon completion, take the vehicle to the predetermined laid out distance and make three trial runs. Record the time in the box below. If it needs to be refined, please do so and record only your final three readings.
8. Compare the results of your design to others in the class.

TRIAL #	DRIVE WHEEL SIZE	DISTANCE TRAVELED	TIME	
1				Average time: _____
2				
3				Average distance: _____
4				
5				Average time: _____
6				Average distance: _____

Activity Analysis

1. Explain how your vehicle converted linear motion into rotary motion and clockwise motion into counter-clockwise motion.

2. List and describe three common devices which use mechanical systems to convert rotary motion to a linear motion, a clockwise motion to a counter-clockwise motion, or enlarging a given motion.

FLUID POWER SYSTEMS

Introduction

Transmitting energy from one location to another with a liquid or gas is called fluid power. There are two basic types of fluid power systems, hydraulic and pneumatic. To perform work, hydraulic systems use a liquid, and pneumatic systems use a gas. The most commonly used liquids are oil and water. The most commonly used gas is air.

A basic fluid power system has a pressure source, control device, an actuator, and a network of conductors. The pressure source in a hydraulic system is often a pump. Pneumatic systems use a compressor for a pressure source. Both hydraulic and pneumatic systems use valves to control fluid pressure, direction, and flow in the system. The device that actually performs the work is called an actuator. The two most commonly used actuators are motors and cylinders. Motors are used when rotary energy is needed to perform a given task. The pressure produced by the pump is used to rotate a turbine inside the motor. Cylinders are used to perform tasks that require linear energy. Pressure produced by the pump is used to push a piston within the cylinder. Conductors are used to connect the various devices together. They contain and direct the flow of fluid in a continuous path called a circuit. The most commonly used conductors are pipes and hoses.

Earth moving equipment and fork lifts use hydraulic systems to move heavy loads. Air ratchets and jack hammers use pneumatic systems to make work easier. Fluid power systems have very few moving parts and require little maintenance. Because they use pipes and hoses, energy can be transmitted over long distances, around corners, and between moving parts. Since pumps and compressors can be powered by internal combustion engines, fluid power systems are often used on vehicles designed to perform heavy work which already have internal combustion engines as their power sources (e.g., tow trucks, dump trucks, bull bulldozers, cranes).

This Technology Education Activity will provide students an opportunity to use fluid power technology to transmit force. During the lab activity, students will build and test a simple fluid power system. When the system is complete, they will use it to apply force to various positions along a lever and make conclusions about the work being performed.

Materials and Supplies

- 1 piece plywood, 3/4" x 12" x 24"
- 1 piece plywood, 3/4" x 10" x 24"
- 2 pieces wood, 3/4" x 6" x 6"
- 1 generic windshield washer pump
- 1 brass aquarium flow valve
- 1 plastic container
- 1 4' length of 1/8" hose
- 1 20 cc medical syringe
- 1 piece wood, 3/4" x 1 1/2" x 12"
- 1 piece wood, 3/4" x 1 1/2" x 21"
- 1 weight hanger and set of weights (science-type)

- 1 12 volt power supply or two 6 volt dry cell batteries and an on-off switch
- A variety of nuts, bolts, screws, and washers
- Water
- 3 latch hooks
- 1 36" length of insulated wire

Problem Statement

Fluid power systems help people perform work. Work is a unit of measurement. It can be determined by multiplying the distance traveled by an object times the amount of force applied to the object. For example, to lift an engine out of an automobile, mechanics often use a hydraulic engine hoist. The amount of work performed by the engine hoist equals the distance traveled by the engine multiplied by the weight of the engine. Many engine hoists have several positions for the hydraulic cylinder. Using your fluid power trainer, determine the advantages of placing the hydraulic unit in various positions.

Making the Fluid Power Trainer (DR # 1 and 2)

1. Cut and assemble the plywood back, base, and vertical supports. Your instructor will provide the nails and/or screws for assembly and will suggest the best way to join the materials.
2. Using the illustration as a guide, lay out and mount the windshield washer pump, syringe, lever, and weights.
3. Cut and install the hoses. Make sure the aquarium flow control valve is installed between the output port of the windshield washer pump and the reservoir.
4. Fill the reservoir with water about three-quarters of the way to the top. Position the reservoir on the trainer and insert the hoses.
5. Connect the positive and negative leads from the windshield washer pump to a power supply. Make sure your power supply and electrical connections are a safe distance away from the water reservoir.

Activity Procedure

1. Complete the following description of how your fluid power system works by using the terms listed below. You may need to use a term more than once.

   - syringe
   - reservoir
   - weight
   - hoses
   - circuit
   - valve
   - pump
   - lever

   With the power supply on, the windshield washer _____ converts electrical energy from the power supply into mechanical energy. The mechanical energy is used to circulate water from the _____. When the flow control valve is closed, it directs water to the _____. The syringe applies a force to the _____. The lever uses the force to lift the _____ a given distance. When the flow control _____ is

open, the tension produced by the weights draw the lever down. As the lever returns to its original position, the syringe pushes the water back into the _____. Turning the power supply off opens the electrical _____ and the windshield washer pump stops circulating water.

2. Place the syringe in position #1. Note the position of the weight. Turn the windshield washer pump on. Open the flow control valve so the syringe travels one inch. Measure and record the distance traveled by the lever in the space provided below.

_____ inches

3. Determine the amount of weight being suspended from the lever. Record the weight in the space provided below.

_____ pounds

4. Turn the windshield washer pump off and open the flow control valve. Using the formula provided below, determine the amount of work performed by the lever and the fluid power system.

Work = Distance x Force

Foot-Pounds = $\frac{\text{Inches}}{12}$ x Pounds

= $\frac{\_\_\_\_\_}{12}$ x _____ Pounds

= _____

5. Place the syringe in position #2. Turn the windshield washer pump on. Open the control valve so the syringe travels one inch. Measure and record the distance traveled by the lever in the space provided below.

_____ inches

6. Using the formula provided, determine the amount of work performed by the lever and the fluid power system.

Work = Distance x Force

Foot-Pounds = $\frac{\text{Inches}}{12}$ x pounds

= $\frac{\_\_\_\_\_}{12}$ x _____ pounds

= _____

7. Place the syringe in position #3. Turn the windshield washer pump on. Open the control valve so the syringe travels one inch. Measure and record the distance traveled by the lever in the space provided below.

_____ inches

8. Using the formula provided, determine the amount of work performed by the lever and the fluid power system.

Work = Distance x Force

Foot-Pounds = $\frac{\text{Inches}}{12}$ x pounds

= $\frac{\_\_\_\_\_}{12}$ x _____ pounds

= _____

9. With the syringe in position #3, increase the weights in small amounts, just until the pump can no longer lift them, if possible. Recrod the weight _____.

10. Place the syringe in position #1. Can it lift the weights? _____

Why? _____

Determine the work it did: Work = distance x force

Force - pounds = $\frac{\text{Inches}}{12}$ x pounds = _____

Activity Analysis

Directions: Circle the best answer or fill in the blank with the correct answer.

1. Using a fluid to transmit energy from one location to another is called _____ technology.

   A. mechanical
   B. electrical
   C. fluid power

2. The distance traveled at the end of the lever _____ as the syringe is moved closer to the pivot point (fulcrum).

   A. increases
   B. decreases
   C. stays the same

3. To perform the greatest amount of work, the syringe needs to be placed in position # _____.

A. 1
B. 2
C. 3
D. any of the above

4. The windshield washer pump is the _____ in your fluid power system.

A. control device
B. actuator
C. pressure source
D. fluid conductor

5. Which of the following is the control device in your fluid power system?

A. windshield washer pump
B. flow valve
C. reservoir
D. syringe

6. Pretend your fluid power trainer is an engine hoist. Which of the following would be the best position for the hydraulic unit if you want to lift a small engine quickly?

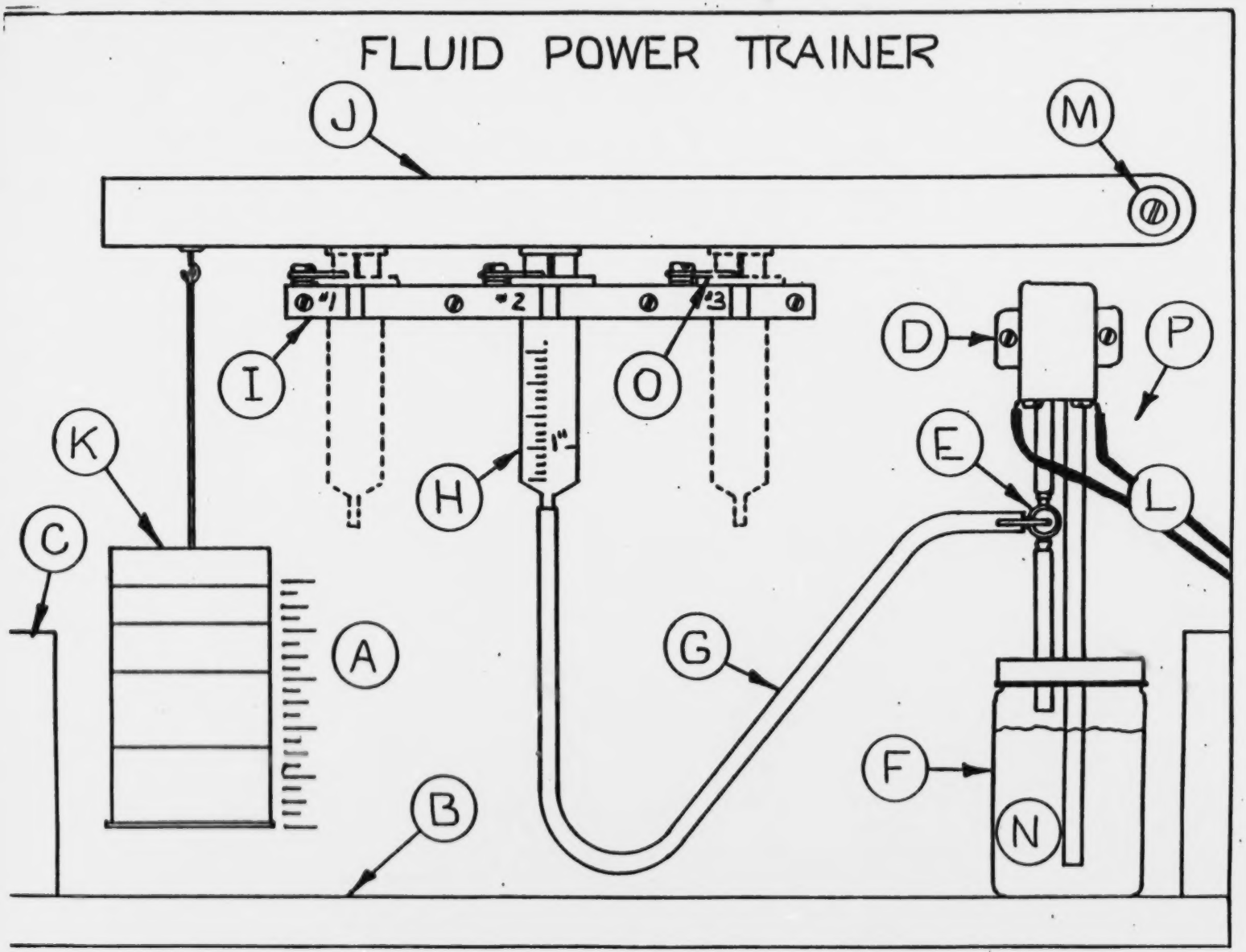
A. position 1
B. position 2
C. position 3
D. any of the above

7. To lift a large engine safely, which position would be best?

A. position 1
B. position 2
C. position 3
D. any of the above

8. List five examples of machines that use fluid power systems to perform work

1. _____
2. _____
3. _____
4. _____
5. _____


FLUID POWER TRAINER
J
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A
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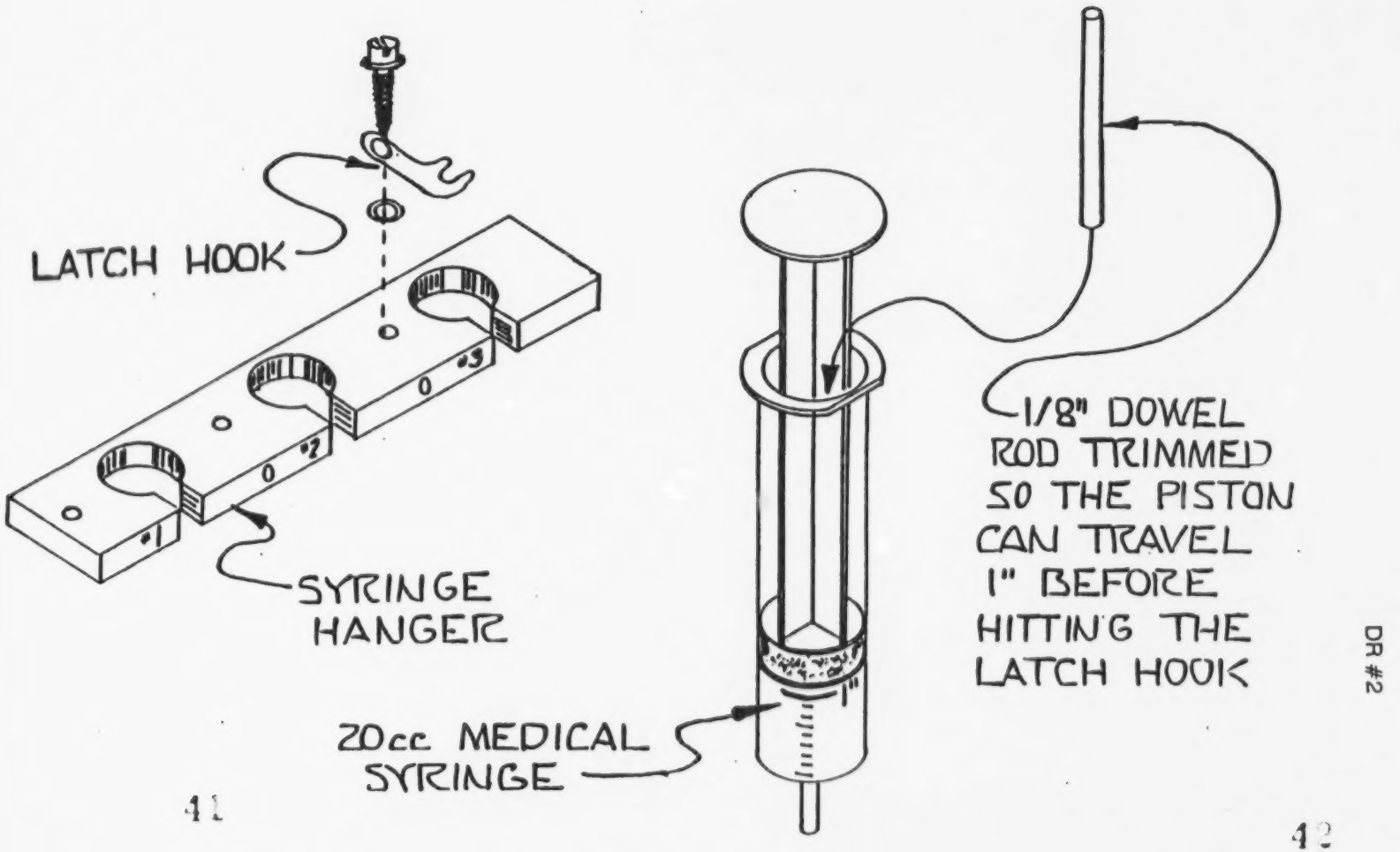
F
B
N
DR #1


LATCH HOOK
SYRINGE HANGER
20cc MEDICAL SYRINGE
1/8" DOWEL ROD TRIMMED SO THE PISTON CAN TRAVEL 1" BEFORE HITTING THE LATCH HOOK

DR #2

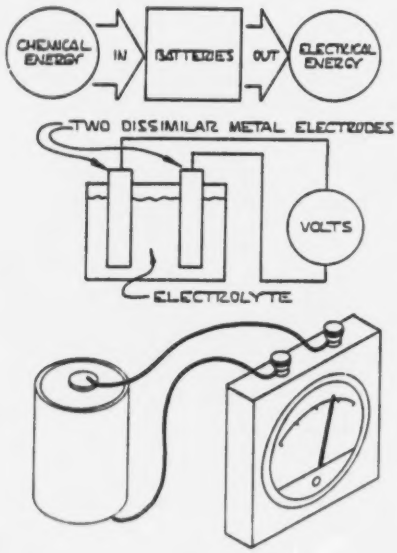
ENERGY TRANSDUCERS

Introduction

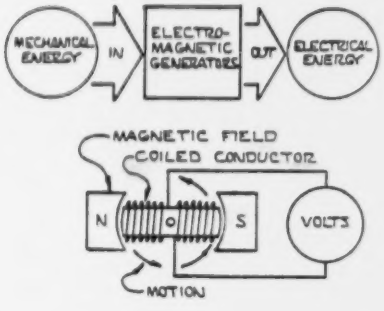
Electricity is the flow of electrons through a conductor. To create electrical current, we need to apply a force that will knock electrons free of their atoms. This force is called electromotive force or emf. Electricity is called a second generation form of energy because we need to use another form of energy to produce emf. Emf can be produced with chemical, thermal (heat), radiant (light), or mechanical energy.

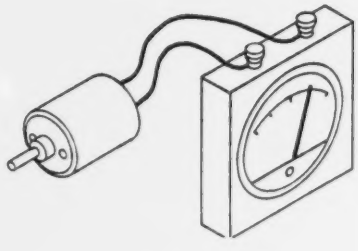
In an electrical circuit, emf is provided by an energy transducer. The energy transducers used in an electrical circuit convert either chemical, thermal, radiant, or mechanical energy into electrical energy. Examples of energy transducers include things like batteries, generators, photovoltaic cells, and thermocouples. All these devices use another form of energy to produce emf.

Batteries use a chemical solution called electrolyte and two electrodes made of different metals to convert chemical energy into electrical energy (see illustration below). When the electrodes are placed in the electrolyte, a chemical reaction occurs. The electrolyte causes one electrode to lose positive ions which gives it a negative charge. The positive ions in turn pull electrons from the other electrode giving it a positive charge. The chemical reaction creates a potential difference across the electrodes. If a conductor is connected across the electrodes, electrons will flow from the negative electrode to the positive electrode until the chemical energy inside the battery is depleted. Batteries are used to power portable devices like radios, flashlights, cameras, and toys.

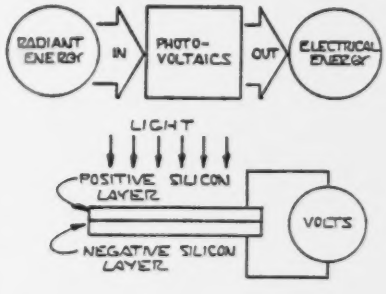


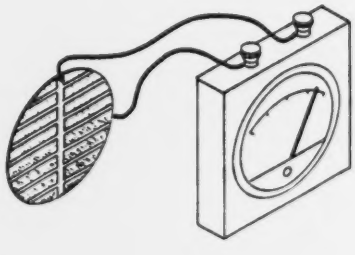
Generators use magnetism to convert mechanical energy into electrical energy (see illustration below). Current flowing through a conductor will produce a magnetic field around the conductor. The opposite is also true. Passing a conductor through a magnetic field will produce current in the conductor. Generators use the relationship between magnetism and current to generate electricity. Three basic elements are needed to generate electricity, a coiled conductor, a magnetic field, and mechanical energy (motion). Mechanical energy is used to rotate coils of wire past magnets. The magnetic field produced by the magnets causes current to flow through the coils. The current flowing through the coils can be used to power electrical devices as long as there is mechanical energy to drive the generator. The electricity you use in your home comes from a generator.



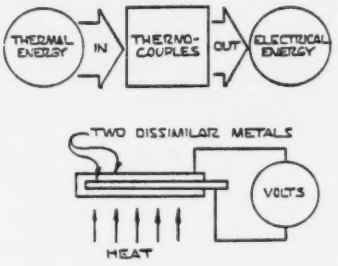


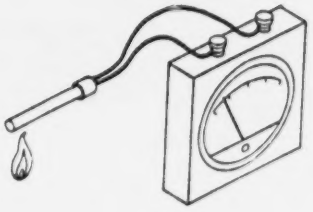
Photovoltaic cells convert radiant (light) energy into electrical energy (see illustration below). The word photovoltaic comes from the word photo (light) and voltaic (generate electricity). Photovoltaic cells are made of two thin layers of silicon crystal. Each layer is specially treated to give them different electrical characteristics. When a photovoltaic cell is exposed to light, electrons flow from the negatively-charged silicon layer to the positively-charged layer. Photovoltaic cells are often used to power small calculators. In addition, photovoltaic cells are used to power the equipment aboard satellites.





Thermocouples convert thermal energy (heat) to electrical energy. When two different metals are put together and heated, a current can be produced. The metals heat at different rates. The difference in temperature between the two metals causes electrons to move. Thermocouples produce a very limited amount of current and can not be used to power devices. They are often used with other devices to measure and control thermal systems. For example, thermocouples are used to signal shut-off valves on gas furnaces and hot water heaters if the pilot light goes out.





Energy transducers produce the force needed to create current in a conductor. The force is measured in volts and current is measured in amperes or amps. Voltage can be measured by placing the test leads of a volt meter across the terminals of an energy transducer. Current is the quantity of electrons that pass a given point in the circuit during a given period of time. One ampere equals 6,250,000,000,000,000,000 electrons passing a point in the circuit in one second. To measure current, the meter needs to be installed in the circuit.

Electricity is called a second generation energy source because another form of energy is needed to create electromotive force. Devices that produce emf are called energy transducers. They convert either chemical, mechanical, radiant, or thermal energy into electrical energy. The emf produced by an energy transducer is measured in volts and current is measured in amperes.

Problem Statement

You use a variety of energy transducers to power electrical devices. The energy needed to light the rooms of your house at night comes from a generator. Your portable stereo and/or tape player uses batteries for electrical energy. If you have a solar powered calculator, it relies on photovoltaic cells for electrical energy. All these energy transducers convert another form of energy into electrical energy. During the following Technology Education Activities, you will be making and experimenting with a variety of energy transducers.

MAKING AND TESTING A BATTERY

Introduction

To make a battery, you need two different metals and an electrolyte. Copper makes a good positive electrode and a galvanized (zinc coated) metal makes a good negative electrode. The electrolyte can be lemon juice, grapefruit juice, or table salt dissolved in water. With these materials you can make one of three batteries. Your teacher will tell you which battery to make.

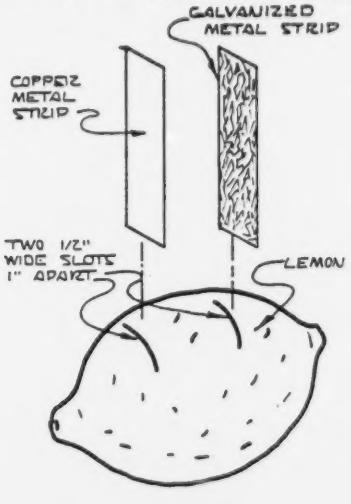
Materials and Supplies

- 1 lemon or grapefruit
- 1 small knife
- 1 strip of galvanized metal, 1/2" wide and 3" long
- 1 strip of copper, 1/2" wide and 3" long
- 1 35 mm plastic film container
- 1 utility knife
- 1 strip of galvanized metal, 1/2" wide and 3" long
- 1 strip of copper, 1/2" wide and 3 " long
- 1/4 cup of lemon juice, grapefruit juice, or salt water
- 1 galvanized piece of metal, about 1" wide and 1" long
- 1 copper penny
- 1 piece of paper towel, about 3/4" wide and 3/4" long
- 2 drops of lemon juice or vinegar
- 1 eye dropper
- 1 homemade cell
- 1 milliamp meter
- 1 volt meter

Making a Citrus Cell

1. You can make a battery out of a piece of citrus fruit. Lemons and grapefruits work the best. They both contain the acid needed to produce the desired chemical reaction.

2. Cut two slots into the top of the fruit with the knife. Make the slots at least 1" apart and 1 1/2" deep (see illustration below).

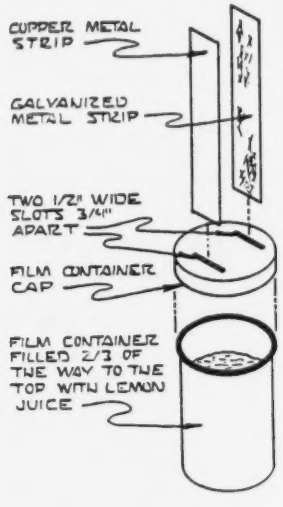


3. Insert the copper strip into one slot and the galvanized strip into the other. Believe it or not, you have just made a battery.

Making a Simple Cell

1. Obtain the needed materials from your instructor.

2. Using the utility knife, cut two 1/2" long slots in the lid of the film container. The slots should be parallel and about 1/2" apart (see illustration below).


COPPER METAL STRIP
GALVANIZED METAL STRIP
TWO 1/2" WIDE SLOTS 3/4" APART
FILM CONTAINER CAP
FILM CONTAINER FILLED 2/3 OF THE WAY TO THE TOP WITH LEMON JUICE

3. Fill the film container about 2/3 full of electrolyte and snap the lid on the container.

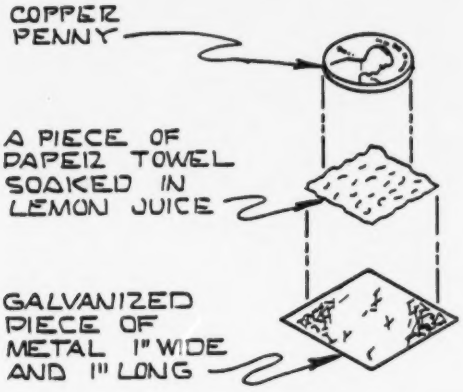
4. Insert the galvanized strip of metal in one slot and the copper strip in the other. Make sure the strips are not touching each other inside the film container. You have just made a simple battery.

Making a Penny Cell

1. Obtain the needed materials from your instructor.

2. Cut out a piece of paper towel about 3/4" wide and 3/4" long. Using the eye dropper, put one or two drops of lemon juice or vinegar on the paper towel until it is saturated.

3. Place the saturated paper towel in the center of the galvanized piece of metal (see illustration below).

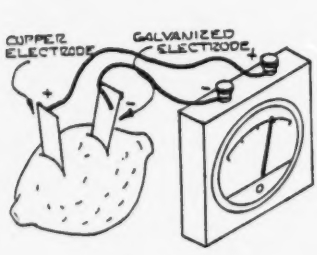


4. Put a penny on top of the saturated paper towel. You have just made a battery sandwich.

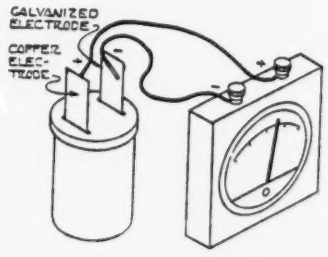
<u>Testing your Cell</u>

1. Obtain the needed materials from your instructor.

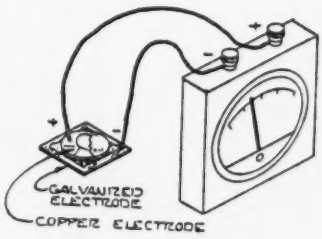
2. Now that you have made a cell, lets see if it works. Batteries use chemical energy to produce electromotive force. Electromotive force is measured in volts. Determine how many volts your battery can produce with a volt meter. Touch the positive lead from the meter to the copper electrode and touch the negative lead to the galvanized electrode (see illustration below). Make sure you have a good connection. Read the meter and record the voltage in the space provided.



_____ volts

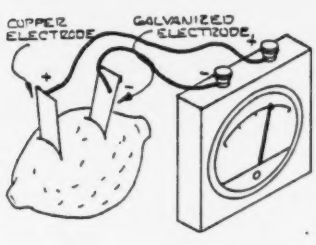


_____ volts

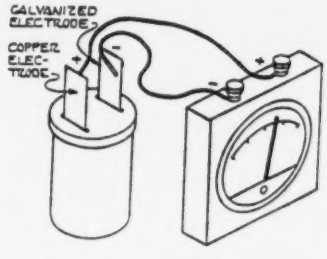


_____ volts

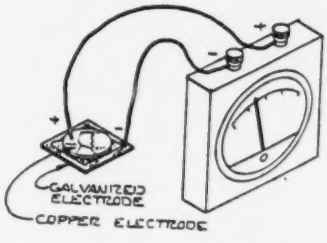
3. Measure the current your battery can deliver using a milliamp meter. Current is measured in amperes. One milliamp is one thousandths of an ampere. Touch the positive lead from the meter to the copper electrode and touch the negative lead to the galvanized electrode (see illustration below). Make sure you have a good connection. Read the meter and record the current in the space provided.



_____ milliamps



_____ milliamps



_____ milliamps

MAKING AND TESTING A BATTERY

Introduction

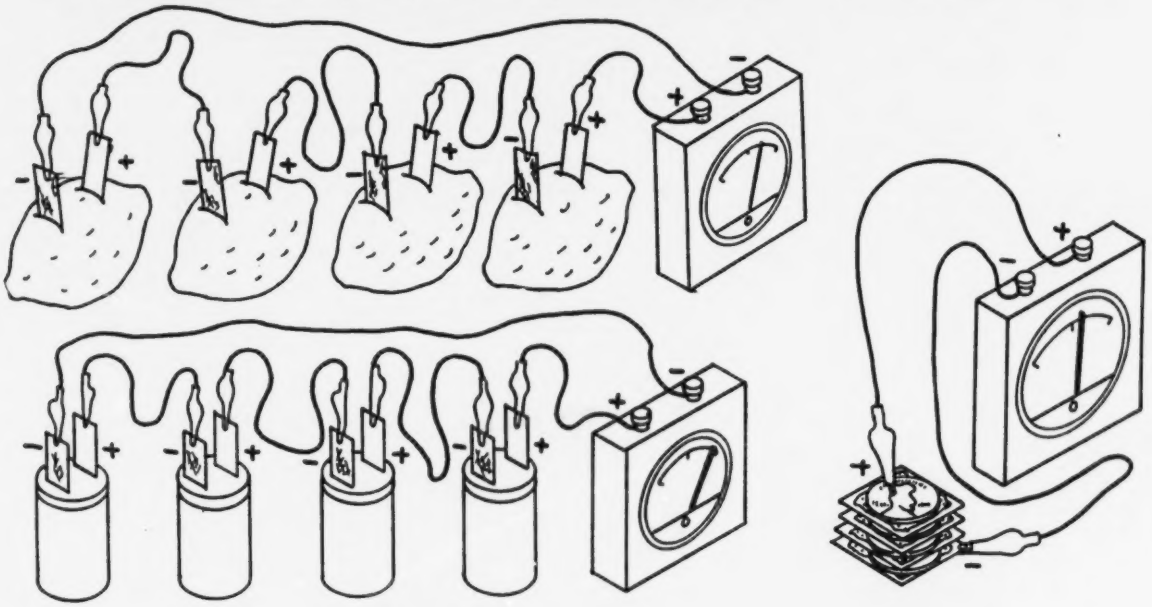
You probably noticed your cell does not produce a lot of volts or deliver a lot of current. Technically speaking, your cell is not really a battery yet. A battery is a collection of cells connected in series. When cells are connected in series, the total voltage will equal the sum of cell voltages. To make a battery that can perform work will require more cells. Use the material provided to make three more cells.

Materials and Supplies

- 4 homemade cells
- 1 milliamp meter
- 1 volt meter
- 6 jumper leads
- 1 LED

Activity Procedures

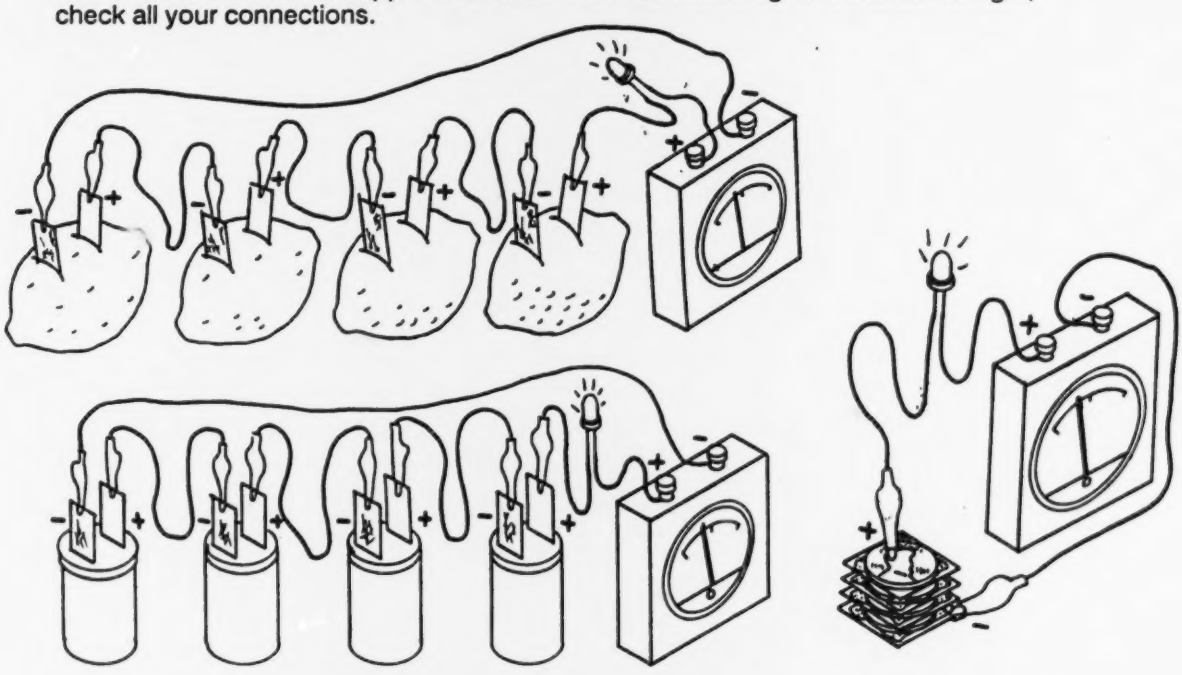
1. Begin by connecting the cells in series. To connect cells in series, the positive electrode from the first cell needs to be connected to the negative electrode of the second cell. The positive electrode from the second cell needs to be connected to the negative electrode of the third cell. This process is continued until all the cells are connected together. Using jumper leads, connect your cells in series (see illustration below). If you are making a battery with penny cells, simply stack the cells one on top of the other.



2. Measure the voltage produced by your battery with a volt meter. Touch the positive lead from the meter to the copper electrode on the fourth cell. Touch the negative lead from the meter to the galvanized electrode on the first cell. Read the meter and record the voltage in the space provided.

Citrus Cell Series	Simple Cell Series	Penny Cell Series
_____ volts	_____ volts	_____ volts

3. Connect an LED to your battery (see illustration below). Make sure the long lead on the LED is connected to the copper electrode. The LED should light. If it does not light, check all your connections.



4. Measure the current in the circuit with a milliamp meter. Connect the positive lead to the negative lead of the LED. Connect the negative lead to the galvanized electrode. Read the meter and record the current in the space provided.

_____ milliamps

Activity Analysis

1. When cells are connected in series, the total voltage is equal to the sum of the _____ voltages.

2. When cells are connected in series, the voltage in the circuit _____. Circle the correct answer.

   A. increases
   B. decreases
   C. stays the same

3. When cells are connected in series, the current in the circuit _____. Circle the correct answer.

   A. increases
   B. decreases
   C. stays the same

4. Batteries convert _____ energy into electrical energy. Circle the correct answer.

   A. mechanical
   B. radiant
   C. chemical
   D. thermal

MAKING AND TESTING A GENERATOR

Introduction

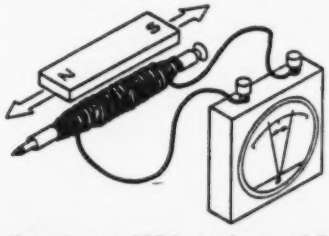
The basic elements needed to make a generator are a coiled conductor, a magnetic field, and motion. You can make a coil with magnetic wire, a magnet can be used to provide the magnetic field, and you can provide the motion. In this lab activity, you will make and test a generator. In addition, you will experiment with a small generator.

Materials and Supplies

- 1 plastic drinking straw
- 30 feet of gauge magnet wire
- 1 steel nail
- 1 magnet
- 1 pair of scissors
- 1 microamp meter
- 1 piece of fine sandpaper
- 1 hobby motor (generator)
- 1 milliamp meter
- 1 volt meter
- 3 jumper leads
- 1 LED

Making and Testing an Electromagnetic Generator

1. Begin by cutting a 2" section off the drinking straw with a pair of scissors. Leaving a 3" lead, wind the wire around the straw. Try to make each turn as neat as possible. Leave a 3" lead at the end of the wire (see illustration below).



2. Insert the steel nail inside the straw. With a piece of fine sandpaper, remove the lacquer finish at the end of each lead. Connect the leads coming from the coil to a meter designed to measure microamperes.

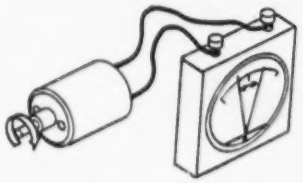
3. Position the magnet so that the north and south poles are parallel with the coil. Move the magnet back and forth along the side of the coil. Try to read the meter. Describe what the meter is doing in the space below.

_____

_____

Testing a Small Generator

1. Start by connecting a small hobby motor to a milliamp meter with jumper leads. Make sure you connect the positive lead from the meter to the positive terminal on the motor. Connect the negative lead from the meter to the negative terminal on the motor (see illustration below). They are usually marked on the motor.



2. When the meter is connected, twist the shaft on the motor as fast as you can. Read the meter and record the current in the space below.

_____ milliamps

3. Connect the motor to a volt meter. Twist the shaft on the motor as fast as you can. Read the meter and record the voltage produced in the space below.

_____ volts

4. If you can produce about 4 milliamps and 1/2 a volt with your motor, try connecting it to an LED (see illustration below). Twist the shaft as fast as you can and see if you can produce enough energy to light the LED.

Activity Analysis

1. Generators convert _____ energy into electrical energy. Circle the correct answer.

   A. mechanical
   B. radiant
   C. chemical
   D. thermal

2. List two examples in which generators are used to create electrical energy.

_____

_____

PHOTOVOLTAIC CELLS

Introduction

Photovoltaic cells convert radiant (light) energy into electrical energy. Unlike batteries and generators, photovoltaic cells have only been available since the mid 1950's. Recent innovations in photovoltaic technology have made them more affordable and efficient. They are used to power small electronic devices, generate electricity in remote areas, provide electricity for energy efficient homes, recharge batteries, and power the electronic equipment on board satellites. They have even been used to power an experimental airplane. New applications for photovoltaic devices are being developed all the time. During this lab activity, you will experiment with photovoltaic cells.

Materials and Supplies

- 1 light source or access to sunlight
- 1 photovoltaic array
- 1 milliamp meter
- 1 volt meter
- 5 jumper leads
- 1 LED

Activity Procedures

Testing a Photovoltaic Cell

1. Obtain the needed materials from your instructor.

2. Locate a single photovoltaic cell in direct sunlight or about three feet away from a light source. Connect a voltmeter to the cell. Using jumper leads, connect the positive test lead to the positive terminal from the cell. Connect the negative test lead to the negative terminal from the same cell. Aim the photovoltaic cell directly at the sun or light source. Read the meter and record the voltage in the space provided below.

   _____ volts

3. Measure the current in the circuit with a milliamp meter. Connect the positive test lead to the positive terminal. Connect the negative test lead to the negative terminal. Read the meter and record the current in the space provided.

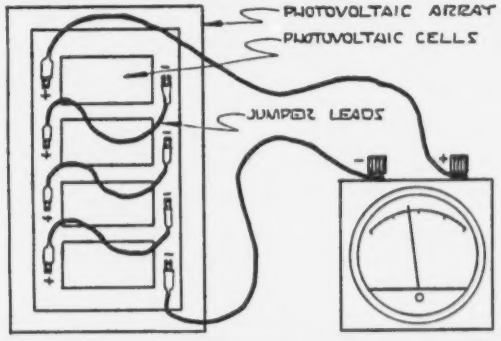
   _____ milliamps

Making and Testing a Photovoltaic Array

1. You probably noticed one photovoltaic cell does not produce a lot of volts or deliver a lot of current. Most applications require a photovoltaic array (see DR #1). A photovoltaic array is basically a collection of photovoltaic cells connected so they produce a higher voltage and/or more current.

2. Obtain a photovoltaic array panel from your instructor.

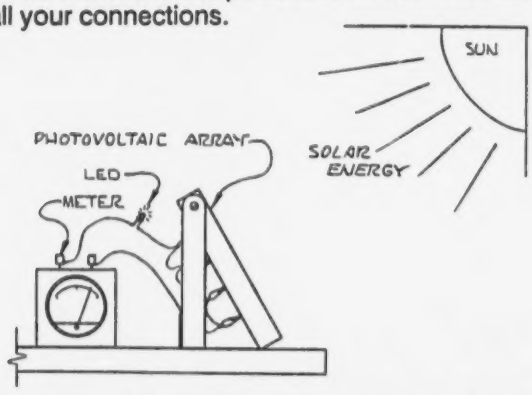
3. To increase the voltage produced, you need to connect the cells in series. When cells are connected in series, their total voltage equals the sum of their individual voltage. To connect cells in series, the positive terminal from the first cell needs to be connected to the negative terminal of the second cell. The positive terminal from the second cell needs to be connected to the negative terminal of the third cell. This process is continued until all the cells are connected together. Using jumper leads, connect the photovoltaic cells in series (see illustration below).



4. Measure the voltage produced by the array with a volt meter. Touch the positive lead from the meter to the positive terminal on the array. Touch the negative lead from the meter to the negative terminal on the array. Read the meter and record the voltage in the space provided.

_____ volts

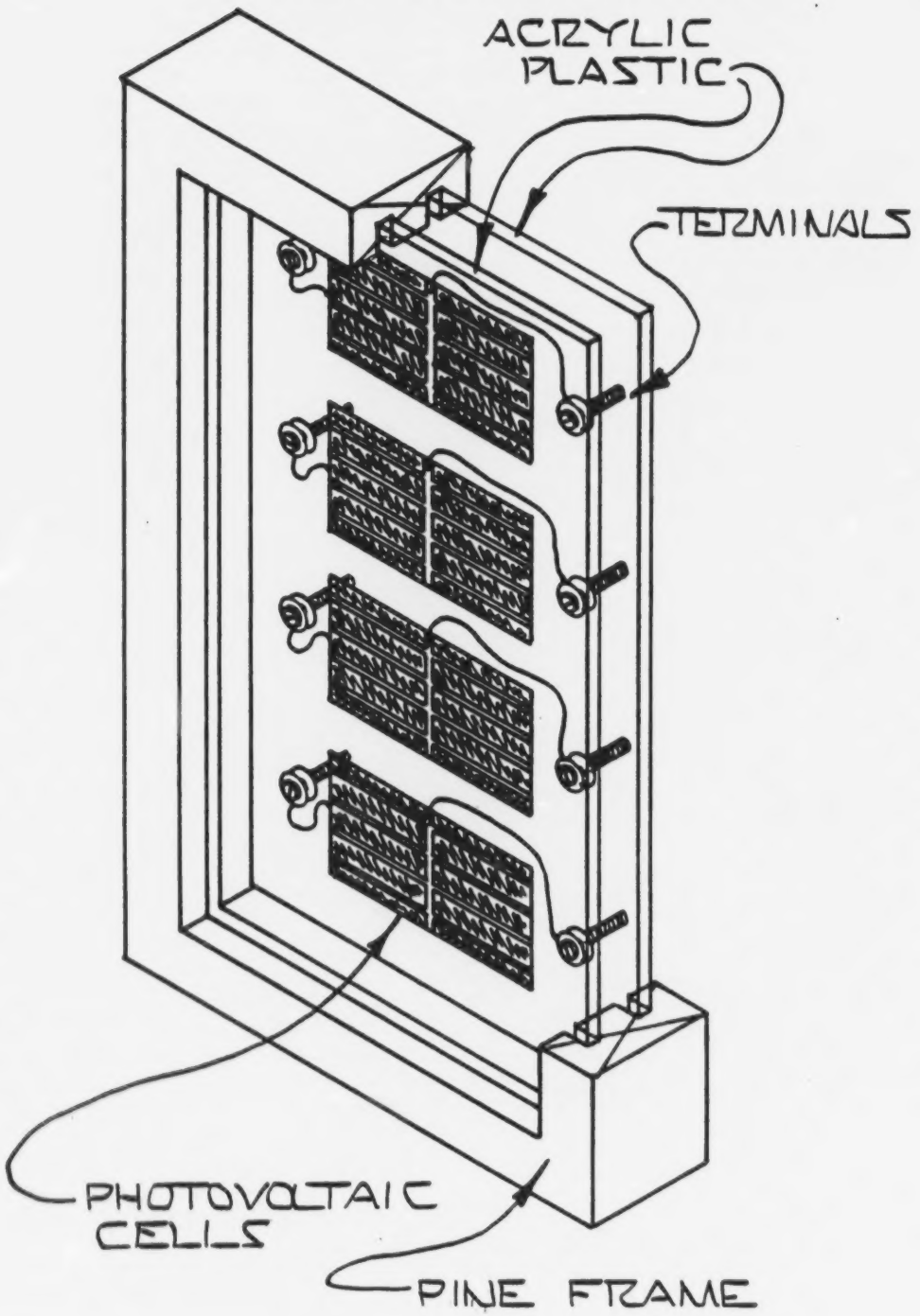
5. Connect an LED to your photovoltaic array (see illustration below). Make sure the long lead on the LED is connected to the positive terminal. The LED should light. If it does not light, check all your connections.



6. Measure the current in the circuit with a milliamp meter. Connect the positive lead to the negative lead of the LED. Connect the negative lead to the negative terminal on the photovoltaic array. Read the meter and record the current in the space provided.

DR #1

PHOTOVOLTAIC ARRAY PANEL



Activity Analysis

1. When cells are connected in series, the total voltage is equal to the sum of the _____ voltages.

2. When cells are connected in a series, the voltage in the circuit _____. Circle the correct answer.

   A. increases
   B. decreases
   C. stays the same

3. When cells are connected in series, the current in the circuit _____. Circle the correct answer.

   A. increases
   B. decreases
   C. stays the same

4. Photovoltaic cells convert _____ energy into electrical energy. Circle the correct answer.

   A. mechanical
   B. radiant
   C. chemical
   D. thermal

THERMOCOUPLES

Introduction

Thermocouples convert thermal (heat) energy into electrical energy. They are commonly used to monitor, measure, and control thermal energy systems. For example, thermocouples are used to measure the temperature of molten metal in foundries. They are commonly used to trigger shut-off valves on gas furnaces and water heaters if the pilot light goes out. During the lab activity you will be experimenting with a thermocouple for a gas furnace or hot water heater.

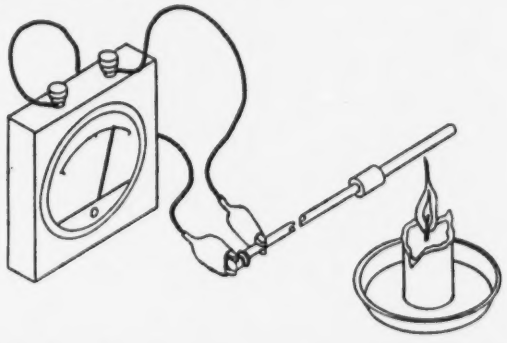
Materials and Supplies

- Thermocouple
- 1 candle
- 1 match
- 1 volt meter
- 1 microamp meter
- 2 jumper leads

Activity Procedures

Testing a Thermocouple

1. Begin by connecting the volt meter to the thermocouple (see illustration below). Use a jumper lead to connect the positive meter lead to the copper tubing on the thermocouple. Use a second jumper lead to connect the negative meter lead to the conductor at the end of the copper tubing.



2. Locate the candle away from flammable materials. Light the candle and place the tip of the thermocouple in the flame. Read the meter and record the output voltage in the space provided.

_____ volts

3. Measure the current in the circuit with a microamp meter. Connect the positive meter lead to the copper tubing coming from the thermocouple. Connect the negative meter lead to the conductor at the end of the tubing. Read the meter and record the current in the space provided.

_____ microamps

Activity Analysis

1. Thermocouples convert _____ energy into electrical energy. Circle the correct answer.

   A. mechanical
   B. radiant
   C. chemical
   D. thermal

2. List two applications for thermocouples.

_____

_____

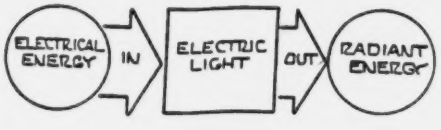
OUTPUT TRANSDUCERS AND CONTROL DEVICES

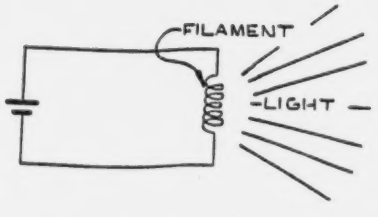
Introduction

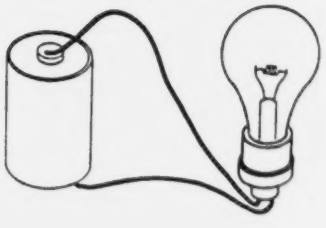
A simple electrical circuit includes an energy transducer, a conductor path, an output transducer, and a control device. The energy transducer converts chemical, mechanical, radiant, or thermal energy into electrical energy. Electrons carry the electrical energy through the conductor path in the form of current. In order to perform work, the energy being carried by the electrons needs to be harnessed and converted into a more useful form of energy.

Output transducers are devices that use electrical energy to perform work. In order to perform work, they convert electrical energy into radiant (light), thermal (heat), mechanical (motion), or sound energy. Common examples of output transducers include things like light bulbs, electrical motors, heating elements, and buzzers.

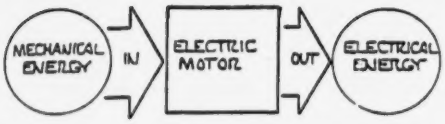
Light bulbs convert electrical energy into radiant (light) energy (see illustration below). Electrical current travels through a thin wire called a filament. The filament is enclosed in a vacuum or surrounded by a gas. The filament restricts the flow of electrons and it becomes white hot. The lack of oxygen inside the bulb prevents it from burning up. The glow from the white hot filament can be used to light an area.

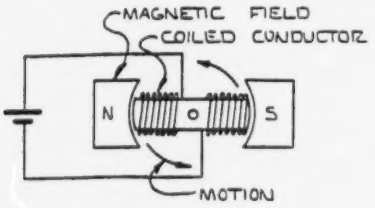


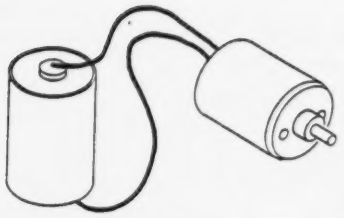




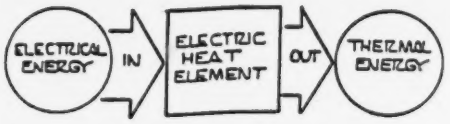
Electrical motors use magnetism to convert electrical energy into mechanical energy (see illustration on the following page). Electrical current is passed through a coil called the armature. The armature is placed between north and south poles of a magnet. Since current is flowing through the armature, it produces a magnetic field. The magnetic field produced by the armature and that produced by the magnets attract each other and the armature turns. As the armature rotates past the magnets, the current is reversed and magnetic poles repel each other. The attraction and repulsion of magnetic fields cause the armature to rotate. Electrical motors are used for things like circulating air in buildings, starting automobile engines, and driving the machines in your laboratory.

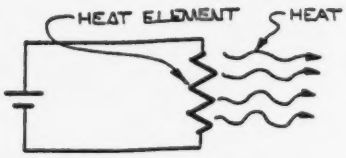


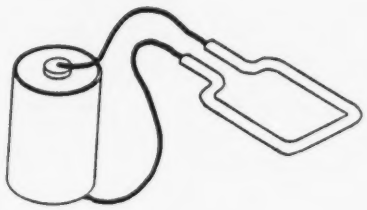




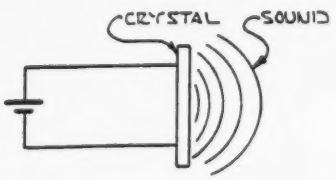
Heating elements use electrical resistance to convert electrical energy to thermal (heat) energy (see illustration below). If you press your hands together and rub them back and forth as fast as you can, you will produce heat. This heat is due to friction. Friction is the product of resistance. In electricity, resistance is opposition to current flow. When a material with high resistance is put in a circuit, there is a lot of electrical friction when the electrons pass through the material. This electrical friction produces heat. Electric space heaters, toasters, hair dryers, clothes dryers, and ranges all use electrical resistance to produce heat.

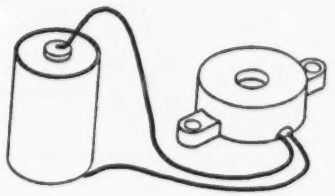






A piezo electric buzzer converts electrical energy into sound energy (see illustration below). When a voltage is applied across a special crystal material, it will distort. If the voltage is applied in controlled pulses, the crystal will vibrate back and forth. These vibrations produce sound waves we can hear. Piezo electric buzzers are commonly used for the alarm on electronic watches.

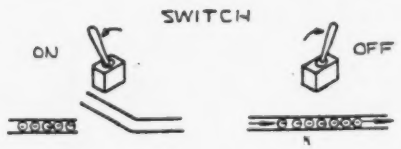




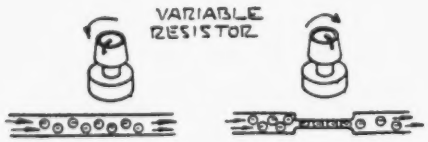
If you want to be able to turn a light on or off, or be able to control the speed of a motor, the circuit needs to include a control device. Control devices allow you to start, stop, and/or regulate current flow in a circuit. Examples of basic control devices include switches, thermostats, photocells, variable resistors, and fuses.

Control devices can be actuated a variety of ways. Most control devices are actuated mechanically. However, some are actuated with heat, light, or a magnetic field. For example, the switches you turn on and off manually are mechanically activated. Outdoor lights that turn on by themselves when the sun goes down are controlled by a light-activated switch. Burglar alarms often use switches that turn on and off with a magnet. The furnace in our home is controlled by a switch that turns on and off with changes in the room temperature.

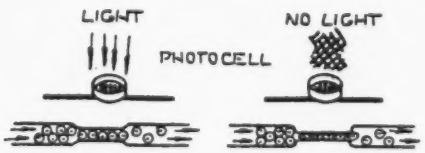
Switches control the flow of electrons much the same way as a drawbridge controls traffic. When the bridge is down, traffic flows smoothly. When the bridge is up, the roadway is incomplete and cars cannot cross. When a switch is closed, current flows smoothly. When the switch is open, the conductor path is incomplete and current cannot flow (see illustration below).



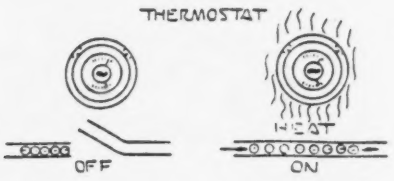
Variable resistors regulate current flow by changing the resistance in a circuit. Variable resistors use conductors that resist the flow of electrons to control current in a circuit. When resistance (opposition to current flow) in a circuit is low, current flow is fast. When resistance in a circuit is high, current flow is slow. Most variable resistors are adjusted manually (see illustration below).



Photocells are resistors that change with light. When they are exposed to bright light their resistance decreases. When exposed to darkness, their resistance is high (see illustration below).



Thermostats use temperature sensitive materials to control current flow. For example, the thermostats used in many homes use two metal strips that form a switch. When they are cold, they touch, the circuit is closed, and the furnace will run until the house warms up. When the house does warm up, one of the metal strips will expand, the circuit will become open, and the furnace will shut off (see illustration below).



Fuses use heat to protect a circuit from an overload. An overload occurs when the current in a wire becomes so great it becomes hot. There is often a danger of fire when an overload occurs. To prevent an overload, many circuits include a control device called a fuse. Fuses are designed to break if their current limit is exceeded. Fuses are used to protect electronic devices and circuits in automobiles.

Together, energy transducers, conductor paths, control devices, and output transducers make up an electrical system. An electrical system can perform work. For example, to start an automobile we put a key in the ignition switch (control device) and turn it to the start position. The chemical energy in the battery (energy transducer) is converted to electrical energy. Electrons flow through the battery cables (conductor path) and carry the electrical energy to the starter motor. The starter motor (output transducer) converts the electrical energy provided by the battery into mechanical energy. The mechanical energy is used to turn the engine until it starts and we release the ignition switch.

Output transducers convert electrical energy to mechanical, thermal, radiant, and sound energy. Control devices are used to start, stop, and regulate the flow of current through a circuit. Control devices can be actuated with mechanical, thermal, radiant, or sound energy. In an electrical system, the energy transducer supplies energy to the circuit, the conductor path carries the energy, the control device controls the flow of energy, and the output transducer uses the energy to perform work.

Problem Statement

You use control devices and output transducers every day. When you enter a dark room, you flip a switch (control device) that turns on a light (output transducer). The switch completes the circuit and supplies electrical energy to the light fixture. The light fixture in turn converts the electrical energy to radiant energy and illuminates the room. During the following Technology Education Activities, students will be making and testing a variety of electrical systems. Each electrical system will be using a different control device and output transducer.

LIGHT CIRCUIT

Introduction

A light seems to go on automatically when we open a refrigerator door, oven door, car door, glove box door, or trunk lid. Even though it seems like magic, you know there are switches controlling these lights. If you have ever tried to find these switches, you know they are usually well hidden. During this lab activity, you will make and test a circuit that turns a light on and off when a door is opened.

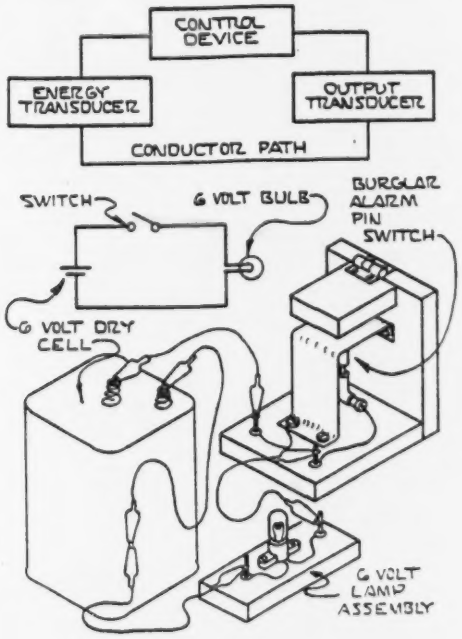
Materials and Supplies

- 1 3 volt power supply
- 1 pin switch or mercury switch
- 1 lamp assembly
- 4 jumper leads
- Voltmeter
- Milliamp meter

Activity Procedures

Making a Light Circuit

1. Read the schematic drawings below. Using the parts listed above, build the circuit as illustrated. NOTE: Be sure to obtain permission from your instructor before using any pieces of equipment.



2. When your light circuit is complete, make sure it works. The light bulb should light when you lift the door. If the light does not work, check all your connections. If it still does not work, ask your teacher for assistance.

Testing your Light Circuit

1. To test your light circuit, you will need a voltmeter and a milliamp meter.
2. Measure and record the voltage across the power supply with a voltmeter. With the light on, touch the positive test lead to the positive terminal of the energy transducer. Touch the negative test lead to the negative terminal of the energy transducer. Read the meter and record the voltage in the space below.

   _____ volts

3. Measure and record the voltage across the light bulb with a voltmeter. With the circuit on, touch the positive test lead to the positive terminal on the lamp assembly. Touch the negative test lead to the negative terminal on the lamp assembly. Read the meter and record the voltage in the space below.

   _____ volts

4. The voltage measured at the energy transducer is _____ the voltage measured at the lamp assembly. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

5. Turn the light off. Install a milliamp meter in the circuit between the lamp assembly and the power supply. Connect the positive test lead to the jumper wire coming from the negative terminal on the lamp assembly. Connect the negative test lead to the jumper going to the negative terminal on the energy transducer.

6. When the meter is installed, turn the light back on. Read the meter and record the current in the space below.

   _____ milliamps

7. Turn the light off. Read the meter and record the current in the space below.

   _____ milliamps

Activity Analysis

1. Current flows through the circuit when the switch is _____. Circle the best answer.

   A. open
   B. closed
   C. open or closed

2. The control device in your circuit is _____ actuated. Circle the best answer.

   A. mechanically
   B. light
   C. heat
   D. magnetically

3. The output transducer in your circuit converts electrical energy to _____ energy. Circle the best answer.

   A. radiant (light)
   B. thermal (heat)
   C. mechanical (motion)
   D. sound

TEMPERATURE CONTROLLED CIRCUIT

Introduction

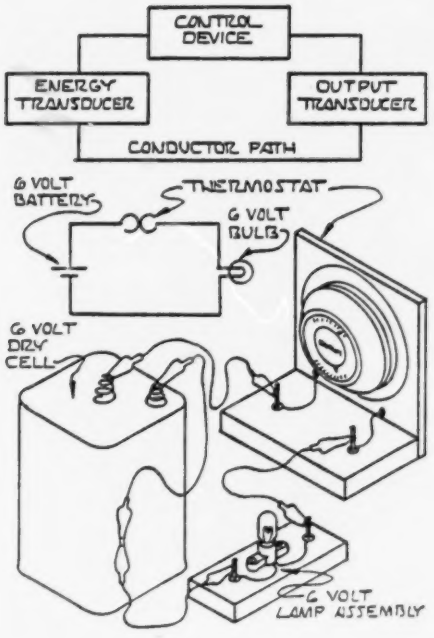
Many electrical systems are temperature controlled. For example, air conditioners, whole house fans, and attic fans are designed to turn on automatically if it becomes too hot in parts of the house. Most automobiles have a warning light that tells the driver if the engine is overheating. During this lab activity, you will make and test a temperature controlled circuit.

Materials and Supplies

- 1 6 volt power supply
- 1 thermostat
- 1 lamp assembly
- 4 jumper leads
- 1 electric hair dryer
- Voltmeter
- Milliamp meter

Making a Temperature Controlled Circuit

1. Read the schematic drawings below. Using the parts listed above, build the circuit as illustrated. NOTE: Obtain permission from your instructor before using any pieces of power equipment.



2. When the light circuit is complete, make sure it works. Set the thermostat for about 75 degrees. Use the hair dryer, blow hot air at the thermostat. Hold the hair dryer at least 9 inches away from the thermostat. When the thermometer on the thermostat reads about 75 degrees, the light bulb should light. When the thermostat cools off, the light should turn off. If the light does not work, check all your connections. If it still does not work, ask your teacher for assistance.

Testing your Temperature Controlled Circuit

1. To test the light circuit, you will need a volt meter and a milliamp meter.

2. Measure and record the voltage across the energy transducer with a volt meter. Touch the positive test lead to the positive terminal of the energy transducer. Touch the negative test lead to the negative terminal of the power supply. Read the meter and record the voltage in the space below.

   _____ volts

3. Measure and record the voltage across the light bulb with a volt meter. With the circuit on, touch the positive test lead to the positive terminal on the lamp assembly. Touch the negative test lead to the negative terminal on the lamp assembly. Read the meter and record the voltage in the space below.

   _____ volts

4. The voltage measured at the energy transducer is _____ the voltage measured at the lamp assembly. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

5. Turn the circuit off by allowing the thermostat to cool or by removing one of the jumper leads on the energy transducer. Install a milliamp meter in the circuit between the lamp assembly and the energy transducer. Connect the positive test lead to the jumper wire coming from the negative terminal on the lamp assembly. Connect the negative test lead to the jumper going to the negative terminal on the energy transducer.

6. When the meter is installed, turn the circuit back on. Use the hair dryer if necessary. Read the meter and record the current in the space below.

   _____ milliamps

7. Turn the circuit off by removing a jumper lead from the energy transducer. Read the meter and record the current in the space below.

   _____ milliamps

Activity Analysis

1. Current flows through the circuit when the switch is _____. Circle the best answer.

   A. open
   B. closed
   C. open or closed

2. The control device in your circuit is _____ actuated. Circle the best answer.

   A. mechanically
   B. light
   C. heat
   D. magnetically

3. The output transducer in your circuit converts electrical energy to _____ energy. Circle the best answer.

   A. radiant (light)
   B. thermal (heat)
   C. mechanical (motion)
   D. sound

LIGHT METER CIRCUIT

Introduction

Electrical systems that can measure light can be very useful tools. Professional photographers use a hand-held light meter to measure the light being reflected on a subject. They use the reading to adjust the exposure on their camera before taking pictures. Some cameras have built-in light meters that automatically adjust the camera to take the best picture possible. During this lab activity, you will make and test a simple light meter.

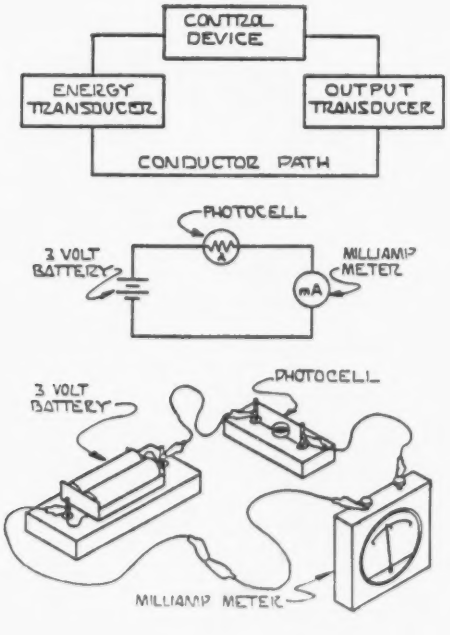
Materials and Supplies

- 1 3 volt power supply
- 1 photocell
- 1 milliamp meter
- 3 jumper leads
- Light meter
- Volt meter

Activity Procedures

Making a Light Meter

1. Read the schematic drawings below. Use the parts listed above to build the circuit as illustrated. NOTE: Obtain permission from your instructor before using any pieces of power equipment.



2. When your light meter is complete, make sure it works. Cover the photocell with your hand, the needle on the meter should move toward zero. Take your hand away from the photocell, the needle on the meter should move across the dial. If the meter movement does not move with changes in light, check all your connections. If it still does not work, ask your teacher for assistance.

Testing your Light Meter

1. Measure and record the voltage across the energy transducer with a volt meter. With the circuit on, touch the positive test lead to the positive terminal of the energy transducer. Touch the negative test lead to the negative terminal of the energy transducer. Read the meter and record the voltage in the space below.

   _____ volts

2. Measure and record the voltage across the milliamp meter with a volt meter. With the circuit on, touch the positive test lead to the positive terminal on the milliamp meter. Touch the negative test lead to the negative terminal on the milliamp meter. Read the meter and record the voltage in the space below.

   _____ volts

3. The voltage measured at the power source is _____ the voltage measured at the meter movement. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

4. The voltage measured at the output should equal the voltage measured at the energy transducer. Another device in the circuit must be using electrical energy. Measure the voltage across the photocell. Touch the positive test lead to the positive terminal on the photocell. Touch the negative test lead to the negative terminal on the photocell. Read the meter and record the voltage in the space below.

   _____ volts

5. Add the voltage measured across the meter movement to the voltage measured across the photocell.

   _____ volts + _____ volts = _____ volts

6. The voltage measured across the energy transducer is _____ to the sum of the voltages measured across the meter movement and the photocell. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

7. Put your hand over the top of the photocell. Read the milliamp meter and record the current in the space below.

_____ milliamps

8. Slowly remove your hand from the photocell and watch the meter. When your hand is completely away, read the milliamp meter and record the current in the space below.

_____ milliamps

Activity Analysis

1. Current flowing through the circuit _____ when the photocell is exposed to light. Circle the best answer.

   A. increases
   B. decreases
   C. stays the same

2. The control device in your circuit is _____ actuated. Circle the best answer.

   A. mechanically
   B. light
   C. heat
   D. magnetically

3. The output transducer (milliamp meter) in your circuit converts electrical energy to _____ energy. Circle the best answer.

   A. radiant (light)
   B. thermal (heat)
   C. mechanical (motion)
   D. sound

VARIABLE SPEED ELECTRIC MOTOR CIRCUIT

Introduction

Our world is full of motor driven devices, portable power tools, golf carts, tape players, electric fans, and food processors to name just a few. Many of these motor driven devices have speed controls. During this lab activity, you will make and test a circuit that features a variable speed electric motor.

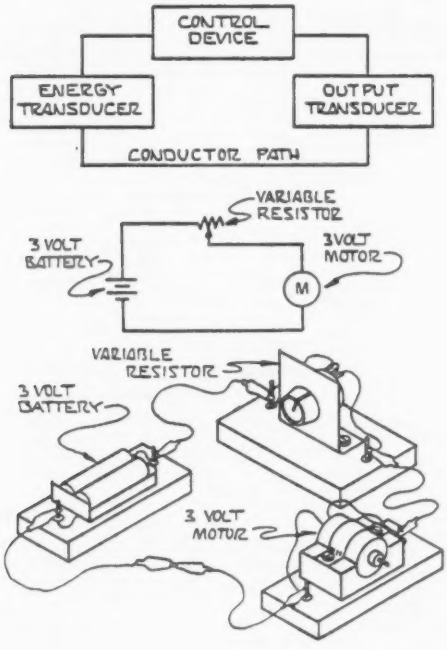
Materials and Supplies

- 1 3 volt power supply
- 1 10k-ohm potentiometer with on/off switch
- 1 3 volt hobby motor
- 4 jumper leads
- Volt meter
- Milliamp meter

Activity Procedures

Making a Variable Speed Electric Motor Circuit

1. Read the schematic drawings below. Using the parts list above, build the circuit as illustrated. NOTE: Obtain permission from your instructor before using any power equipment.



2. When your motor circuit is complete, make sure it works. The motor should begin to turn when you turn the knob on the variable resistor. The speed of the motor should increase as you turn the knob. If your motor does not turn, check all your connections. If it still does not work, ask your teacher for assistance.

Testing your Variable Speed Electric Motor Circuit

1. To test your motor circuit, you will need a voltmeter and a milliamp meter.

2. Measure and record the voltage across the energy transducer with a volt meter. With the circuit on, touch the positive test lead to the positive terminal of the energy transducer. Touch the negative test lead to the negative terminal of the energy transducer. Read the meter and record the voltage in the space below.

   _____ volts

3. Set the variable resistor so your motor is turned as slowly as possible. Measure the voltage across the motor with a volt meter. With the motor turning, touch the positive test lead to the positive terminal on the motor. Touch the negative test lead to the negative terminal on the motor. Read the meter and record the voltage in the space below.

   _____ volts

4. The voltage measured at the energy transducer is _____ the voltage measured at the motor. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

5. The voltage across the energy transducer should be the same as the voltage measured across the load. There must be another device in the circuit using electrical energy. Measure the voltage across the variable resistor. Touch the positive test lead to the positive terminal on the variable resistor. Touch the negative test lead to the negative terminal on the variable resistor. Read the meter and record the voltage in the space below.

   _____ volts

6. Add the voltage measured across the variable resistor to the voltage measured across the motor.

   _____ volts + _____ volts = _____ volts

7. The voltage measured across the energy transducer is _____ the sum of the voltages measured across the resistor and the motor. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

8. To check the statement above, adjust the resistor so the motor is turning as fast as possible. Measure the voltage across the resistor. Record its voltage in the space provided. Measure the voltage across the motor. Record the voltage in the space provided. Add the two voltages together

_____ + _____ = _____

9. The voltage measured at the resistor plus the voltage measured at the motor is _____ the voltage measured at the energy transducer. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

10. Turn the circuit off. Install a milliamp meter in the circuit between the motor and the energy transducer. Connect the positive test lead to the jumper wire coming from the negative terminal of the motor. Connect the negative test lead to the jumper wire going to the negative terminal on the energy transducer.

11. When the meter is installed, turn the motor on. Slowly decrease the resistance in the circuit by turning the knob while watching the milliamp meter.

Activity Analysis

1. The current in the circuit _____ when the resistance is decreased. Circle the best answer.

   A. increases
   B. decreases
   C. stays the same

2. The control device in your circuit is _____ actuated. Circle the best answer.

   A. mechanically
   B. light
   C. heat
   D. magnetically

3. The output transducer in your circuit converts electrical energy to _____ energy. Circle the best answer.

   A. radiant (light)
   B. thermal (heat)
   C. mechanical (motion)
   D. sound

ALARM CIRCUIT

Introduction

Our world is full of alarms that tell us a process is complete or warn us when something is wrong. For example, microwave ovens often beep when the cooking cycle is finished. In some automobiles, a buzzer will sound if you leave your keys in the ignition, do not have your doors completely closed, leave the head lights on, or do not buckle your seat belt. Sometimes, we need to take some form of action to turn alarms off. During this lab activity, you will make and test an alarm circuit.

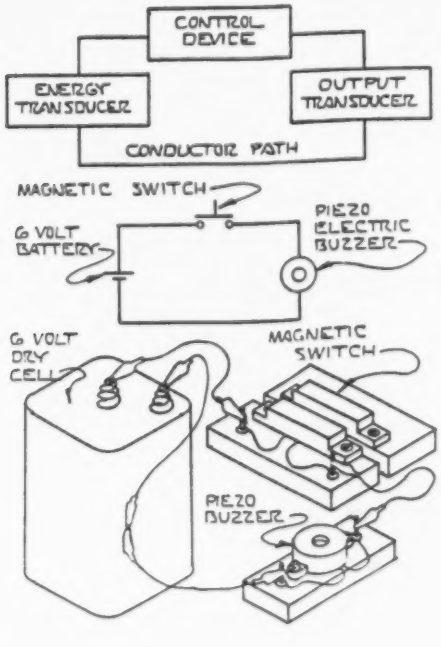
Materials and Supplies

- 1 6 volt power supply
- 1 magnetic switch that is normally open
- 1 piezo electric buzzer
- 4 jumper leads
- Volt meter
- Milliamp meter

Activity Procedures

Making a Simple Alarm Circuit

1. Read the schematic drawings below. Using the parts list above, build the circuit as illustrated. NOTE: Obtain permission before using pieces of power equipment.



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2. When your alarm circuit is complete, make sure it works. When the magnet is removed from its base, the buzzer should sound. When the magnet is returned to its base, the buzzer should stop. If the buzzer does not sound, check all your connections. If it still does not work, ask your teacher for assistance.

Testing the Light Circuit

1. To test your alarm circuit, you will need a volt meter and a milliamp meter.

2. Measure and record the voltage across the energy transducer with a volt meter. With the circuit on, touch the positive test lead to the positive terminal of the energy transducer. Touch the negative test lead to the negative terminal of the energy transducer. Read the meter and record the voltage in the space below.

   _____ volts

3. Measure and record the voltage across the buzzer with a volt meter. With the circuit on, touch the positive test lead to the positive terminal on the buzzer. Touch the negative test lead to the negative terminal on the buzzer. Read the meter and record the voltage in the space below.

   _____ volts

4. The voltage measured at the energy transducer is _____ the voltage measured at the buzzer. Circle the best answer.

   A. greater than
   B. less than
   C. equal to

5. Turn the circuit off. Install a milliamp meter in the circuit between the buzzer and the energy transducer. Connect the positive test lead to the jumper wire coming from the negative terminal on the buzzer. Connect the negative test lead to the jumper going to the negative terminal on the energy transducer.

6. When the meter is installed, trip the alarm. Read the meter and record the current in the space below.

   _____ milliamps

7. Turn the circuit off. Read the meter and record the current in the space below.

   _____ milliamps

Activity Analysis

1. Current flows through the circuit when the switch is_____. Circle the best answer.

   A. open
   B. closed
   C. open or closed

2. The control device in your circuit is _____ actuated. Circle the best answer.

   A. mechanically
   B. light
   C. heat
   D. mechanically

3. The output transducer in your circuit converts electrical energy to _____ energy. Circle the best answer.

   A. radiant (light)
   B. thermal (heat)
   C. mechanical (motion)
   D. sound

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FOSSIL FUELS
AND
ENERGY CONSERVATION

FOSSIL FUELS AND ENERGY CONSERVATION

Suggested Learning Objectives

Upon completion of the Fossil Fuel and Energy Conservation unit, students will be able to:

A. Define and properly use common fossil fuel and energy conservation **terminology** like bituminous, distillation, reserves, infiltration, insulation, and fractionation. SC1

B. Describe the basic fossil fuel **processes** like surveying, drilling, refining, piping, mining, burning, and transporting.

C. Describe basic energy conservation **processes** like auditing, insulating, conserving, monitoring, and adjusting.

D. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with fossil fuels and energy conservation (e.g., auditors, mining equipment, geological surveys, and insulating materials).

E. Discuss the major milestones in the **history** and evolution of fossil fuels and energy conservation including the discovery of oil fields in Pennsylvania, Texas and Alaska, the development of continuous mining techniques, the 1973 oil embargo, and the introduction of fluidized-bed combustion. SS2

F. Identify and evaluate **career** opportunities associated with fossil fuels and energy conservation (e.g., energy auditor, coal miner, insulation contractor, geologist) based on their interests, talents, and career expectations.

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when using fossil fuels and participating energy conservation activities. PH3

H. Identify basic **applications** for fossil fuel energy resources like heating living space, generating electricity, powering vehicles, fueling industrial equipment, and manufacturing pharmaceuticals and synthetic materials. SC1

I. Describe the environmental and societal **impacts** associated with obtaining, refining, transporting, and burning fossil fuels including acid rain, air pollution, land disruption, oil spills, mining accidents, and pneumoconiosis (black lung disease). SC2

J. Forecast the national consequences of dependence on fossil fuels and the potential benefits of energy conservation movements. SC2

K. Identify the common energy products produced from fossil fuel energy resources including coal, natural gas, gasoline, lubricants, kerosene, butane, propane, and diesel fuel.

L. Describe the basic techniques used to locate, obtain, refine, and utilize fossil fuels like magnetic and seismic surveying, offshore oil drilling, longwall coal mining, strip mining, and fluidized-bed coal combustion. SC4

M. Describe how science concepts like conduction, radiation, and convection apply to energy conservation, techniques and technologies. SC1

N. Conduct a basic energy audit to identify opportunities to conserve energy by measuring insulation, identifying infiltration points, and assessing life style. SC4

O. Develop, implement, and evaluate a plan to reduce energy waste and promote energy conservation.

P. Apply basic mathematical concepts to do things like calculate the BTUH load of a structure, compute the efficiency of an electrical device, and figure the number of kilowatt hours of electricity used by a household. MA1

Q. Evaluate the effectiveness of various energy conservation techniques based on cost, pay back and life style considerations.

R. Demonstrate energy consciousness by integrating energy conservation into the students' lifestyle and purchasing energy efficient consumer goods and services.

S. Evaluate appliances based on cost, specifications, and energy efficiency ratings.

Suggested Learning Activities

1. Explain how energy audits are used to evaluate structures for energy efficiency and to identify opportunities to conserve energy. Provide students an energy audit check list and have them conduct an energy audit of their homes. Include things like monitoring electricity utilization, measuring attic insulation, inspecting thermostat settings, and checking windows, doors, and receptacles for air infiltration. Have students use their data to formulate and prioritize a list of energy conservation recommendations for their parents to consider.

2. Explain how aerodynamics and payload affect the energy efficiency of land transportation vehicles. Using model CO2 cars, a timer, a starting system, and a track, have small groups of students modify and test their cars to determine the effects of added weight and aerodynamic obstructions on the car's elapse time. Ask students to identify trends in automobile and truck designs that improve energy efficiency.

3. Discuss the variables that affect an automobile's performance and fuel efficiency. Using a simple check list, have students evaluate their family automobile for energy efficiency. Include things like monitoring gas mileage, keeping a log, inspecting maintenance records, checking tire inflation, and reducing excess weight in the trunk. Have them use the data to formulate and prioritize a list of energy conservation recommendations for parents to consider.

4. Discuss how people waste energy every day by leaving lights on, letting the water run, and not adjusting their thermostat at night. Ask students to identify other bad habits that waste energy. Have students plan and implement an energy conservation campaign at home with slogans, signs, posters, and fliers. Ask students to monitor the amount of energy used by their family before, during, and after their energy conservation campaign. Use the data to evaluate effects of the campaign on their family's energy utilization behavior. Ask students why it is important for their generation to conserve energy.

5. Explain the role of fossil fuels as energy resources for generating electricity. Using a popular computer program, have teams of students run a simulated power plant. Include tasks like monitoring systems, addressing breakdowns, and meeting the demands for electrical energy. Have students evaluate the cost, pollution and safety considerations associated with using fossil fuels to generate electricity.

6. Discuss the role of the boiler, turbine, generator, distribution grid, and consumer in the energy conversion process. Have groups of students build and test model power plants. Each model will need a dry cell battery to represent a boiler, two hobby motors linked together to represent the turbine and generator, and several low voltage light bulbs to represent utility company customers. The battery will power the first motor, the first motor will drive the second motor, and the second motor will generate electricity needed to illuminate the light bulbs. Have each group determine their power plant's efficiency by dividing the power calculated between the second motor and the bulbs by the power calculated between the battery and the first motor and multiplying the total by 100. Discuss how much energy is lost in the energy conversion and distribution process. Ask students to identify the advantages and disadvantages of having centralized utility companies.

7. Discuss how electricity is distributed to communities from several power plants by means of a distribution grid. Using the model power plants made during the activity above, have students create a model distribution grid featuring several power plants and network of customers. Determine the energy supply and demand relationship between the utility and its customers by adding additional consumers (bulbs) to the grid, disconnecting power plants (simulators) from the grid, and disconnect consumers (bulbs) from the grid. Ask students to explain why some utility companies promote energy conservation during the summer, provide lower rates after peak hours, do not want to build new power plants, and how energy conservation can affect the cost of electricity.

8. Introduce students to the concept of diminishing returns and discuss how it applies to energy conservation. Explain how to calculate the BTUH load for a small structure and determine the cost of heating the structure. Have students determine the cost-effectiveness of adding additional insulation, installing storm windows, and/or caulking seams by selecting improvements, recalculating he BTUH load, and refiguring the costof heating the structure. Have students compare the money saved by making improvements to the cost of the improvements. Ask students to identify the most cost-effective energy conservation improvements.

9. Demonstrate how heat escapes from a structure by means of conduction, radiation, and convection. Have students build a cardboard model of a house. Using a budget, have students purchase and install things like rigid insulation, fiberglass insulation, double glazing, and heat mirror to insulate their structure and reduce heat loss. Using a container of hot water as a heat source, monitor the interior and exterior temperature of the enclosure for a given period of time. Use the data collected to determine the number of BTU's lost per hour. Calculate the efficiency of structure insulation by dividing the number of BTU's lost by the cost of the insulation. Ask students to identify the most cost-effective insulation materials and strategies.

10. Discuss sources of acid rain, how it is produced, and the impact it has on the environment. Using several small potted plants, determine the impact of acid rain in plant life by watering and spraying half the plants with pure water and the other half with water with a high PH level. Have students discuss ethical and international issues surrounding acid rain.

11. Discuss the milestones in the history and evolution of fossil fuels and energy conservation systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

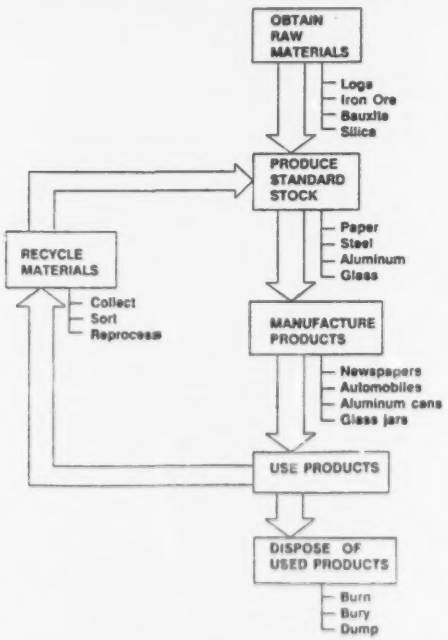
12. Discuss the career opportunities in fossil fuels and energy conservation systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to fossil fuels and energy conservation systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

RECYCLING MATERIALS

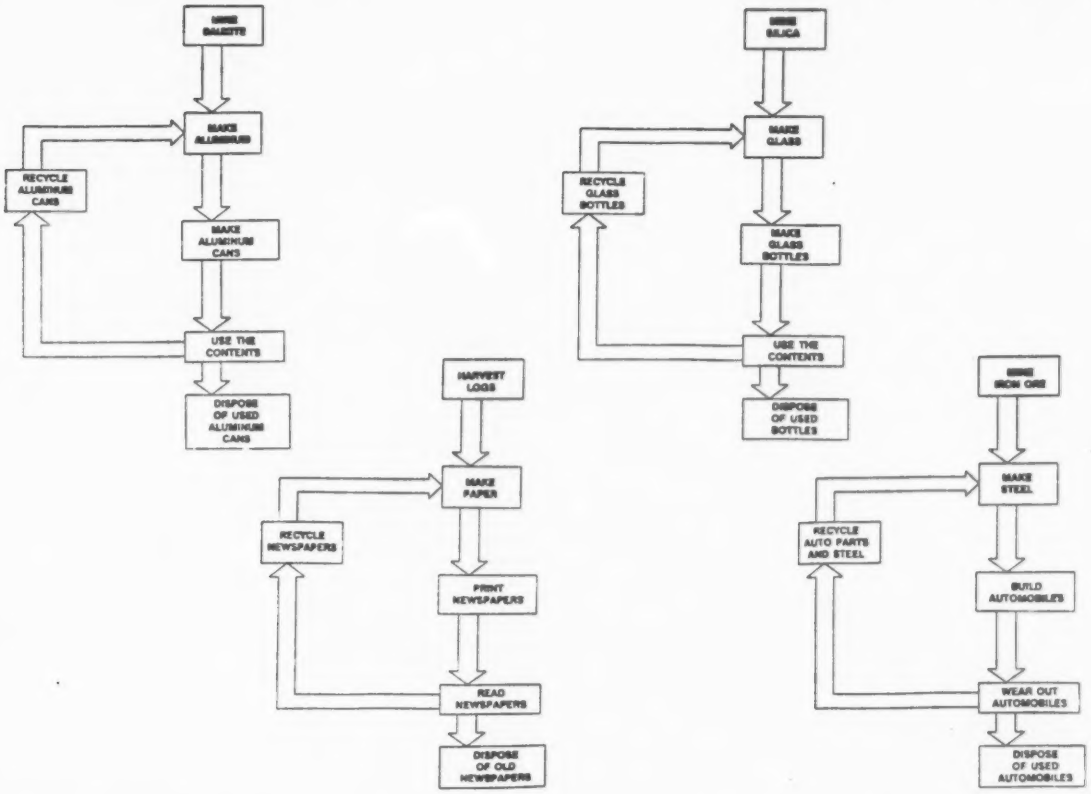
Introduction

We live in a "throwaway" society. When we go to the grocery store to buy food, our purchases are packed in paper bags. We use the bags to transport our groceries from the cart to our trunk, and from our trunk to our kitchen. After the groceries are put away, the bags are often thrown out. While at the grocery store, most of us buy beverages in throw-away aluminum cans or plastic bottles. When we prepare canned goods, we throw away the can. A lot of the food we purchase is packaged in glass jars. Unfortunately, once we have removed the contents, we throw away the jars. One trip to the grocery store can result in a garbage can full of throwaway paper, plastic, glass, and metal containers. Many of these containers are made of materials that can be recycled.

All materials have a life cycle (see illustration below). Even though they are not really alive, they are created, used to serve the needs of humankind, and then thrown away. The average person in the United States throws away about a ton of trash every year. Unfortunately, you can not really throw anything away; it has to be put somewhere. Most of our garbage is buried in land fills. Even though we can not see it after it has been buried, it is still there. In some parts of the United States, people are running out of places to put their garbage.



One way to solve our garbage disposal problem is to recycle a lot of the materials we throw away (see illustrations on following page). This means short circuiting their life cycle. Instead of throwing useful materials away, we could reprocess them into new products. With recycling, old newspapers become new newspapers, old aluminum cans become new aluminum cans, and old glass jars become new glass jars. Some experts feel more than half of what we throw away could be recycled.



Recycling can help us conserve our natural resources. For example, recycling one ton of steel can conserve about 1 1/2 tons of iron ore. Recycling one ton of paper can help replace and preserve one acre of harvestable trees.

In addition to saving natural resources, recycling conserves energy. For example, making steel from scrap in an electric furnace requires about one quarter of the energy needed to produce steel from new ore. Making aluminum products from recycled cans requires about five percent of the energy needed to make aluminum from bauxite. Using returnable bottles instead of aluminum can save even more energy. Making paper with recycled paper requires half the energy needed to make paper from trees.

Recycling also reduces many forms of pollution. Poorly planned land fills can contaminate nearby well water. Burning garbage in an incinerator can produce air pollutants. Dumping garbage on the land or in the water often results in land, air, and water pollution. Recycling reduces the need to burn, bury, or dump garbage. Thus, recycling can play an important role in solving our pollution problems.

Recycling materials involves a series of technological processes. These processes include:

- collecting
- sorting
- reprocessing

We are all familiar with the collection process. The local disposal company sends a truck down your street and picks up garbage and loads it into a garbage truck. Some communities have special containers for recyclable materials. When people want given materials to be recycled, they must deposit them in one of the containers. When the containers are full, workers from the recycling center collect the recyclable materials. When industry disposes of recyclable materials, the materials are put into special containers. A special truck drops off an empty container and picks up the full container and transports the materials to the recycling center.

During the sorting process, the garbage is separated into categories. In terms of recycling, it is very important to separate things like aluminum from steel, clear glass from colored glass, and newspaper from ledger paper. The sorting process is often performed by people like you. When we collect newspapers or aluminum cans for recycling, we are separating these materials from other materials. Sometimes, the sorting process is performed at a recycling center. For example, when automobiles are recycled, they are compressed and shredded into small pieces of scrap. The scrap travels over a magnetic drum. The magnet attracts the iron and steel scraps and separates them from other materials like rubber, plastic, and aluminum. However, in most cases, the best time to sort materials for recycling is before they are collected.

During reprocessing, the materials are broken down and used to make new products. For example, to make an automobile, metal ore is mined and transported to a steel mill. Inside the steel mill the ore is melted in furnaces and processed into steel. The steel is then used to make auto parts. The auto parts are assembled into an automobile. The average life of an automobile is about seven years. When the automobile is no longer worth repairing, it usually ends up in a salvage yard. There, many of its parts are removed, rebuilt, sold, and reused. The rest of the car is compressed, shredded, and melted down. The molten steel is used to make new auto parts and the process starts all over again.

Other recyclable materials are reprocessed in a similar manner. Glass is crushed, melted down, and used to make new glass products. Newspapers are shredded, reduced to pulp, and used to make new paper. Aluminum cans are shredded, melted down, and used to make new aluminum cans. Even organic materials like food scraps, glass clippings, and leaves can be chopped up and processed in to fertilizer.

The following set of Technology Education Activities will introduce students to the concept of recycling. Through the experience, students will learn the effectiveness of landfill, demonstrate how to recycle used paper into new paper, and conduct a recycling campaign.

BIODEGRADABILITY OF MATERIALS IN LANDFILL

Introduction

There is an assumption that if buried, many materials (e.g., paper, food by-products, lawn clippings) will break down and decay. This technology-based activity will test this assumption.

Materials and Supplies

- Lawn shovels
- Rubber gloves
- Collection of assorted waste materials (paper, plastic garbage bags, food scraps, old newspapers, lawn clippings, leaves)
- Fifty pound lawn roller
- An area of school property designated for test plots
- Camera

Activity Procedures

This activity is designed to be conducted on a yearly or bi-yearly basis. Therefore, the first year this activity is conducted, two plots should be established. One plot should be analyzed after several months, and another should remain buried and analyzed the following year, then reestablished for students in years to come. Thus, after the first year, the activity can be conducted in conjunction with other energy conservation activities and will not require a long period of time to achieve results. The directions that follow are written to reflect an established sample landfill plot.

1. Obtain a picture of the contents of a landfill from your instructor. The picture will allow you to study the condition of the waste material before it was buried. In addition, the pictures will contain information on how much the material weighed when buried.

2. Using a shovel, dig until buried waste material is exposed. Using gloves, remove waste material from the test plot. After removing the material, complete the question on the data collection sheet (SH #1).

3. Once the waste material has been analyzed, properly dispose of the remaining contents. NOTE: Sort out any recyclable material or as recyclable materials as possible.

4. Next, collect an assortment of waste materials that can be buried and analyzed in the future. Before burying, lay out all the materials and take a picture showing the condition of the waste. Once the picture has been developed, label and date the picture. Your teacher will store the photograph for future classes. Additionally, each item should be weighed and the original weight recorded. After the contents have been recorded, bury the material in the appropriate test plot. Cover the material with dirt, using a 50 pound lawn roller, compact the dirt onto the waste material.

Activity Analysis

Answer the following questions based on your experience.

1. Is it true that most buried materials break down and decay over a period of time? Explain your answer.

_____

_____

2. How can landfills be made more efficient?

_____

_____

3. Based on your findings, what materials seemed to decompose faster than others?

_____

_____

Biodegradability of Material

Data Collection Sheet

1. After removing the waste, describe what effect the burying of the material had on the object. Use the original pictures as a guide.

_____

_____

_____

_____

2. Use the original weight of the material to determine the what percentage of the material has decomposed during the test period. This is done by dividing each sample decomposed weight by it original weight.

	ITEM	SAMPLE WT.	ORIGINAL WT.	% DECOMPOSED
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				

RECYCLING PAPER

Problem Statement

Demonstrate how paper is recycled.

Materials and Supplies

Each group of two students will need the following:

- One kitchen blender
- One clothes iron
- One tablespoon of corn starch
- One teaspoon of bleach
- One gallon of water
- One plastic tub
- Material for the paper making screen
- One 4 1/2" x 6 1/2" piece of window screen
- Four 3/4" x 3/4" x 6 1/2" pieces of wood
- Four 3/4" x 3/4" x 3" pieces of wood
- One heavy duty stapler gun with staples
- One stack of old newspapers

Activity Procedure

1. Divide into groups of two.

2. Pour approximately two cups of water into the blender container.

3. Add one tablespoon of corn starch and one teaspoon of bleach. The corn starch will strengthen the paper and the bleach will whiten it.

4. Tear a section of newspaper into tiny pieces. Put the pieces of newspaper into the blender until the mixture reaches the full mark. Blend the mixture until it has a slurry-like consistency. NOTE: Be sure to have your instructor check the mixture before mixing.

5. Pour the mixture into a plastic tub. With screen facing up (DR #1), place the open frame on top of the screen frame. Hold both of the frames together and dip the assembly into the slurry mixture. Scoop up a portion of the mixture and distribute it evenly over the top of the screen.

6. Allow the water to drain through the screen back into the plastic tub. The drained mixture should be between 1/8" and 1/4" thick.

7. After most of the water has drained off, remove the top frame. Lay a clean piece of paper across the top of the mixture. Carefully press the mixture to remove as much excess water as possible. After pressing the mixture, carefully lift the frame and wipe the bottom of the screen with a paper towel. Continue blotting the mixture and wiping the screen to remove as much water as possible.

8. Lay several sheets of dry newspaper over the top of a flat surface. Carefully turn the screen frame upside down, and flop the pulp mixture onto the dry newspaper. Carefully lift the screen of the pulp mixture. NOTE: If the pulp sticks to the frame, use a putty knife to peel it off.

9. Place a piece of dry newspaper over the top of the pulp. Press the newspaper on the pulp with a hot clothes iron. Make sure to keep the iron moving during the pressing phase. After most of the moisture has been removed, allow the paper to air dry for 24 hours.

Activity Analysis

1. State three advantages of recycling paper.

_____

_____

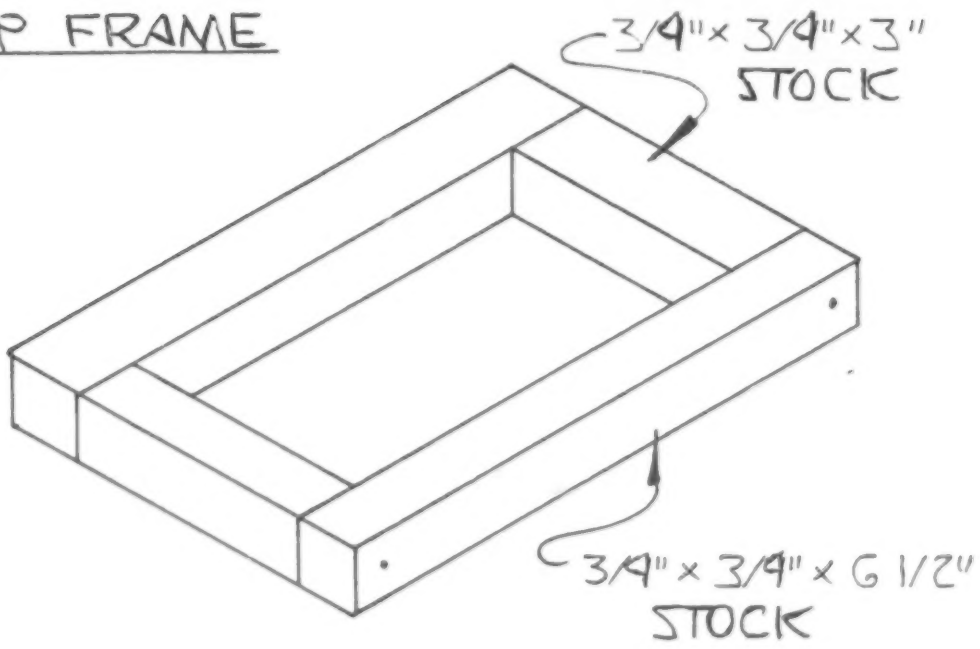
_____

2. Identify three businesses or companies that use recycled paper.

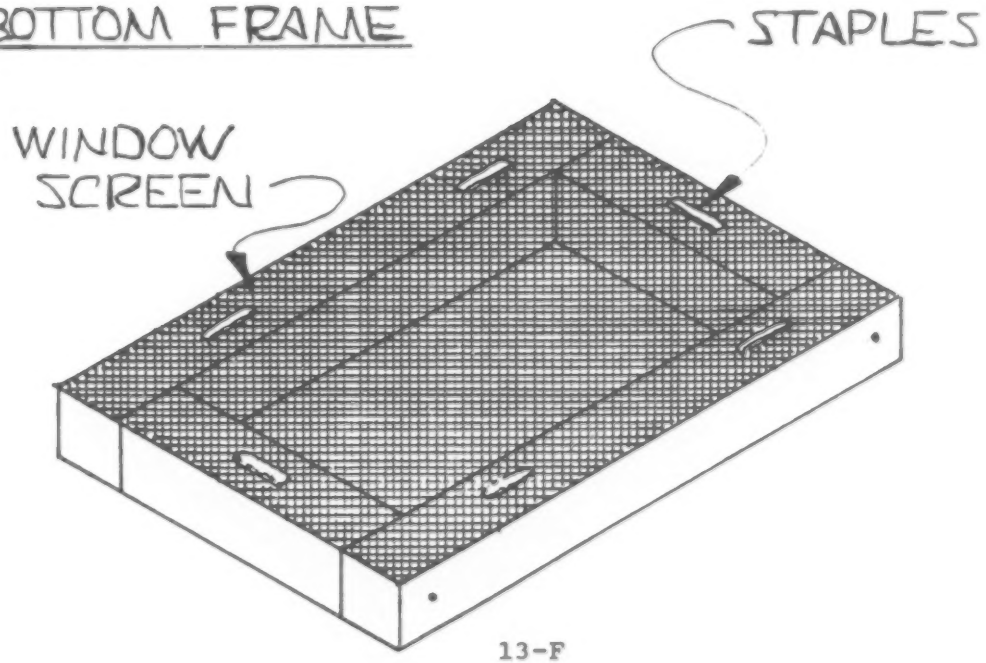
	Name of Business	Use of Recycled Paper
A.	_____	_____
B.	_____	_____
C.	_____	_____

PAPER MAKING HARDWARE

TOP FRAME



BOTTOM FRAME



13-F

RECYCLING CAMPAIGN

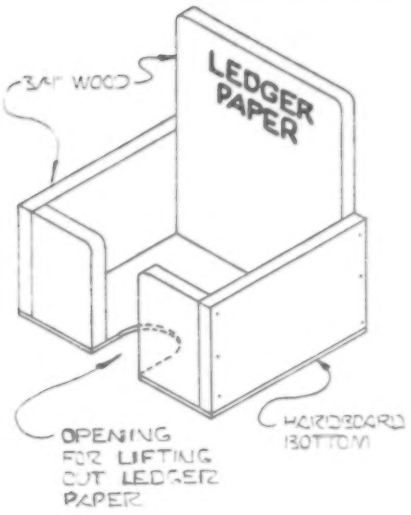
Problem Statement

Recycling small quantities of recyclable materials can defeat the purpose of recycling. With the current status of recycling technology, one can easily use more energy collecting and transporting materials than recycling will save. Therefore, it is important to collect enough recyclable materials to make the effort worthwhile.

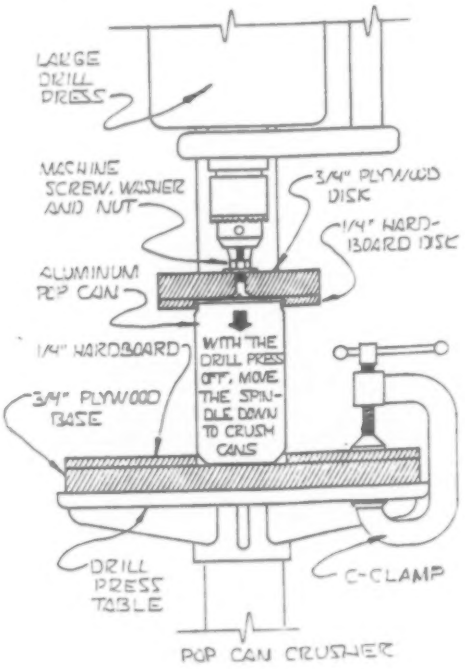
One strategy for collecting large quantities of recyclable materials is to conduct a recycling campaign. During a recycling campaign, a group of people work together to promote recycling and to collect recyclable materials. In addition to conserving natural resources, saving energy, and protecting our environment, a recycling campaign will make people aware of the need to recycle materials. During the following learning activities, you will plan and execute a recycling campaign in your school.

Materials and Supplies

- Collective containers (e.g., specially marked garbage cans) (DR #1)
- Plastic bags to store aluminum cans
- String to bind paper
- Can crusher (DR #2)



DR #1



DR #2

Activity Procedures

Planning a Recycling Campaign

1. The first step in planning a recycling campaign is to identify companies that recycle materials in your community. You do not want to collect a truck load of recyclable materials only to learn the nearest recycling center is 100 miles away. Even worse, if no one is able to recycle your materials locally, you could create a pollution and waste disposal problem for your school. In the blanks provided, list the recycling centers in your community, the materials they recycle, and identify how much they will pay for each recyclable material.

Recycling Center Number One

Name: _____

Materials: Purchase Price:

_____ _____

_____ _____

_____ _____

Recycling Center Number Two

Name: _____

Materials: Purchase Price:

_____ _____

_____ _____

_____ _____

Recycling Center Number Three

Name: _____

Materials: Purchase Price:

_____ _____

_____ _____

_____ _____

2. Identify your recycling options. Using the information you have gathered, circle the materials your class could collect and have recycled locally.

   A. newspapers
   B. ledger paper
   C. aluminum cans
   D. glass
   E. other _____

3. Select the best recyclable material for your recycling campaign. Discuss each of the recycling options. Identify the options that will allow you to collect the most materials with the least amount of effort for the greatest financial return. Write the name of the material you have selected in the space below.

   _____

4. Once you have identified the material you want to recycle, develop a material collection strategy. First identify collection containers. For example, if you are going to collect aluminum cans, label a plastic garbage can for recycling and place it next to other garbage cans. When students finish their lunch, they can put their waste paper in the regular garbage cans and deposit their aluminum cans in the recycling container.

   There are two major considerations when establishing containers for recyclable materials. The first consideration is to make sure the container is appropriate for the material being collected. When you select or design a container, you want to minimize the need to handle the material after it has been collected. The container should help organize the material it will hold. For example, if you were collecting ledger paper, you would want to use a container that creates nice neat stacks. Such a container might look like a box with about the same dimensions as a piece of paper (see DR # __). The second consideration when establishing recycling containers is to make sure people know what to put into the container. Clearly label the container so people are encouraged to recycle the material.

   Using SH #5, sketch the container(s) that will be used to collect your recyclable materials. Show how you will label the container and provide the dimensions if necessary.

Sample Recycling Container
Work Sheet

5. Identify how and when the materials will be collected. For example, if you are collecting ledger paper and have established a collection container in every classroom, who is going to collect the paper? When is the best time to collect the paper? Where will the paper be stored after it has been collected? These are questions that need to be answered before you conduct your recycling campaign. Plan your collection strategy by answering the following questions.

Who will collect the materials? _____

_____

_____

How will the materials be collected? _____

_____

_____

When will the materials be collected? _____

_____

_____

Where will the materials be stored? _____

_____

_____

6. Identify how the materials will be transported from your school to the recycling center. The type of vehicle needed depends on how much material is collected, how often the materials will be transported to the recycling center, and how long the recycling campaign will be run. During the transportation stage, use as little energy as possible. It is more efficient to transport a large quantity of material in one vehicle, but you may not be able to store large quantities of materials until you have a truck load. If the recycling center is close, you could make several trips and still save energy by recycling the material. If you are collecting aluminum cans, consider crushing them before you store them (see DR #2 for the pop can crusher). Discuss the storage and transportation considerations. Using the space provided, describe strategies for transporting materials to the recycling center.

_____

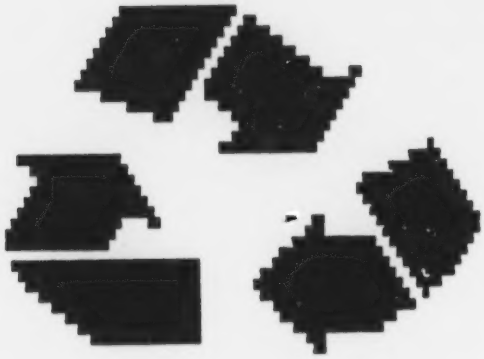
_____

_____

Promoting the Recycling Campaign

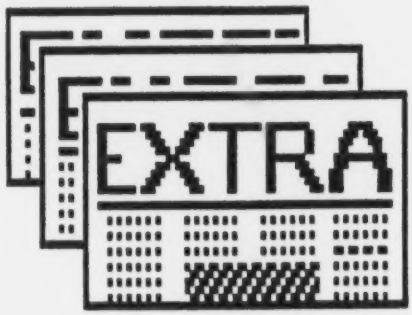
If a recycling campaign is to be successful, it needs to be promoted. People need to be informed about the campaign and how they can participate. One way to promote recycling and the campaign is to make posters. The poster can present the advantages of recycling and how to participate in a recycling campaign (see sample below). Using SH #2, sketch a plan for a recycling poster. When the sketch is complete, use the tools and materials provided by your teacher to make a poster.

RECYCLING SAVES ENERGY



AND OUR NATURAL RESOURCES

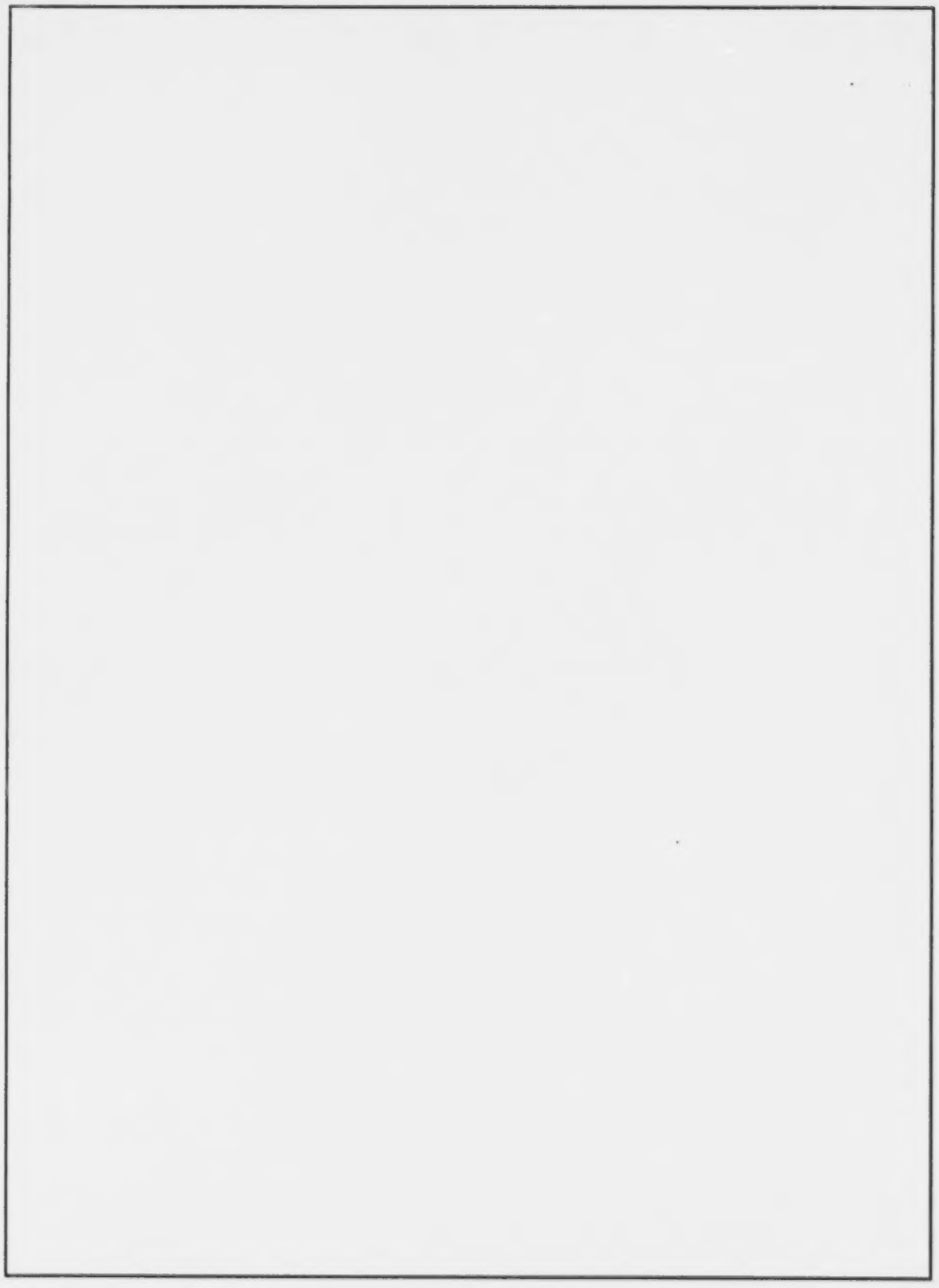
SAVE A TREE



RECYCLE YOUR OLD NEWSPAPERS

SH #2

NOTES



Sample Recycling Campaign Poster

Executing the Recycling Campaign

After carefully planning and promoting, you are now ready to execute the recycling campaign. Place collection containers in strategic locations throughout the school. Place posters in appropriate locations in the school. Begin collecting recyclable materials.

Once you have collected a batch of recyclable materials, prepare it for the recycling center. For example, if you are collecting ledger paper, inspect the paper to see that it meets the recycling center's specifications. For example, some recycling centers will not accept paper containing staples, crayon, or glue.

After the material has been inspected and sorted, prepare it for storage and transportation. One of the goals of recycling materials is to reduce pollution. Therefore, package and store the materials as neatly as possible. If you are collecting ledger paper, package it in grocery bags. If you are collecting aluminum cans, crush them to save space. Because they may still contain a few drops of liquid, store them in plastic garbage bags. If you are collecting newspapers, store them in cardboard boxes from a local grocery or department stores.

Keep accurate records describing how many pounds of material are collected during the recycling campaign. Place each package of recyclable material on a scale and record its weight on the chart provided. After you have collected enough material, transport it to the recycling center.

Date	Total Pounds Collected
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Reporting the Results of the Recycling Campaign

Share the results of your recycling campaign with the school community. After all, their contribution helped make the campaign a success. They need to know they helped make a difference. When you report the results, consider using your school newspaper or PA system to report how many pounds of recyclable materials were collected and recycled. If you were compensated for the materials, report how much money was raised.

Activity Analysis

Directions: Read each statement carefully. Circle the letter of the answer you think best answers the question.

1. Recycling is _____.

   A. using raw materials to make new products
   B. burning, burying, and dumping waste materials
   C. reusing materials to make new products
   D. using standard stock to make new products

2. The average person in the United States throws about _____ of trash every year.

   A. 100 pounds
   B. 500 pounds
   C. 1000 pounds
   D. one ton

3. Most of the communities in Illinois dispose of their garbage by _____.

   A. burying it in landfills.
   B. burning it is incinerators
   C. dumping it at garbage dumps
   D. dumping it in large bodies of water

4. Experts feel we could recycle about _____ what we throw away.

   A. 1/8
   B. 1/4
   C. 1/2
   D. 3/4

5. Recycling can help _____.

   A. conserve our natural resources
   B. save energy
   C. reduce pollution
   D. all the above

6. To preserve one acre of harvestable trees, we need to recycle about one ton of _____.

   A. aluminum
   B. paper
   C. steel
   D. glass

7. Automobile salvage yards recycle _____.

A. auto parts and steel
B. paper and cardboard
C. aluminum and copper
D. glass and plastic

8. Burning garbage in an incinerator often results in _____.

A. air pollution
B. water pollution
C. land pollution
D. all the above

9. The raw material used to make paper is _____.

A. iron ore
B. bauxite
C. trees
D. silica

10. Separating clear glass from colored glass is an example of _____.

A. collecting
B. sorting
C. transporting
D. reprocessing

11. Shredding and melting down aluminum cans is an example of _____.

A. collecting
B. sorting
C. transporting
D. reprocessing

12. Having the garbage picked up in front of your house is an example of _____.

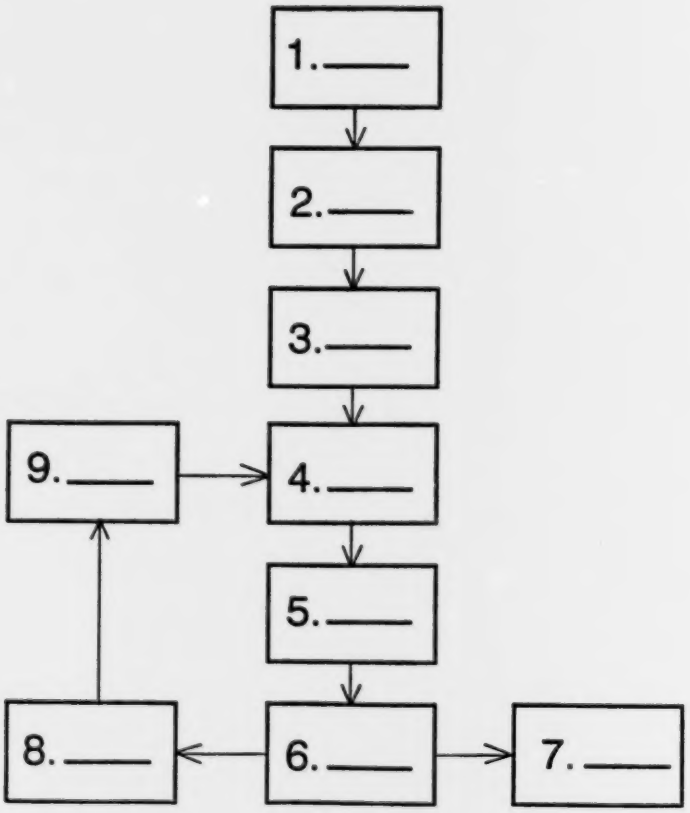
A. collecting
B. sorting
C. transporting
D. reprocessing

13. Which of the following recycling processes are performed if you save, crush, and drop off your aluminum cans at a recycling center?

A. collecting
B. sorting
C. reprocessing
D. all the above

14. Using the items listed below, complete the flowchart illustrating the life cycle of an automobile.

A. use mining techniques to extract iron ore from the earth
B. use the automobile until it is not worth repairing
C. process the iron ore into standard stock in a steel mill
D. sell the automobile to a salvage yard for recycling
E. use the steel to manufacture auto parts
F. remove, rebuild, sell and reuse the parts from junked automobiles
G. use the auto parts and other materials to manufacture automobiles
H. use the molten steel to manufacture new auto parts
I. compress, shred, and melt the scrap steel from junked automobiles



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"Resource Recycling," 1615 N. W. 23rd St., Suite One, P. O. Box 10540, Portland, OR 97210. Phone: (503)227-1319. $18.00/year.

Filmstrips:

Recycling Resources. National Association of Recycling Industries, Inc., 330 Madison Avenue, New York, NY 10017. Cost: Free, but borrower pays return postage. Availability: Book 30 days in advance.

Videotape:

"Kid Power - What the World Needs Now." Available through: Capital Recycling, P. O. Box 751, Springfield, IL 62705. A brief statement about how young people can impact our environment through conservation efforts. Geared toward upper grade and junior high. Capital Recycling also has the materials available.

"Waste Disposal." #4 of the Human Community Series. Available through: Illinois State Board of Education, Television Library, 100 North First Street, Springfield, IL 62777. Send for the videotape catalog for more possible listings. Many tapes can be duplicated for future use.

SOLAR ENERGY

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SOLAR ENERGY

Suggested Learning Objectives

Upon completion of the Solar Energy unit, students will be able to:

A. Define and properly use common solar energy **terminology** like glazing, insulation, thermal mass, and air stratification. SC1

B. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with solar energy utilization (e.g., site, thermal mass, heat transfer fluid).

C. Identify and report the major milestones in the **history** and evolution of solar energy technology including the development of native American cliff dwellings, photovoltaics, and solar farms. SS2

D. Identify and evaluate **career** opportunities associated with solar energy utilization (e.g., solar home designer, solar energy systems installer, photovoltaic lab technician) based on their interests, talents, and career expectations.

E. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when using solar energy. PH3

F. Identify the basic **applications** for solar energy technologies including heating living space, heating water, powering electronic devices, providing a climate for growing plants, and generating electricity. SC1

G. Identify the technological **impacts** of solar energy technology including decentralization of energy resources, life style changes, new architectural styles, conservation of fossil fuels, and visual pollution. SC2

H. Describe the basic solar energy **processes** like collecting, storing, controlling, and distributing.

I. Forecast the potential effects of solar energy utilization on things like fossil conservation, building costs, air pollution, and lifestyle. SC2

J. Identify the basic elements required to collect, convert, distribute, store, and control energy from the sun.

K. Distinguish between and identify examples of direct, indirect, and isolated gain passive solar energy systems. SC1

L. Evaluate how geographical, seasonal, and technological variables affect the cost-effectiveness and energy efficiency of solar energy technologies. SC2

M. Compare and contrast the cost-effectiveness of a given solar energy system based on the cost of fossil fuel energy, the costs associated with solar energy technology, and the system performance. SC2

N. Describe the advantages and disadvantages of air and hydronic active solar energy systems. SC2

O. Describe the collection, conversion, storage, control, and distribution technologies used in passive, active, photovoltaic, and large scale solar energy systems.

P. Design, build, and test a small scale solar energy system that addresses a simple thermal or electrical energy problem.

Q. Analyze and present the best solar energy system for a given problem based on design, energy, cost, and aesthetic considerations.

R. Apply basic mathematical concepts to do things like determine heat gain, identify solar collector orientation, angles, and calculate the power produced by a photovoltaic device. MA1

S. Design, build, test and evaluate simple solar energy devices like parabolic collectors, flat plate collectors, greenhouses, solar farms, solar furnaces, or photovoltaic arrays.

T. Identify opportunities and develop strategies for integrating solar energy technology into a given structure.

U. Determine the amount of energy produced by a thermal and electrical solar energy system using appropriate tools, techniques, and measuring units.

V. Describe the limitations of solar energy technologies for industrial, commercial, and residential applications. SC2

W. Identify solar energy as an appropriate and viable means of reducing our dependence on fossil fuels.

Suggested Learning Activities

1. After introducing the basic passive solar energy concepts and techniques, have groups of students design, build and test a variety of models representing direct, indirect, and isolated gain systems. Have students monitor the interior temperatures of the models in the sun and in the shade. Discuss the advantages, disadvantages of each design. Ask students to describe what it would be like to live or work in various types of passive solar buildings.

2. After discussing the basic active solar energy concepts and techniques, have groups of students design, build and test a variety of solar collectors. Include flat plate, parabolic, air, and liquid collectors. Monitor and compare the input and output temperatures of the fluid being circulated through the collectors. Discuss the advantages, disadvantages, and potential applications of each solar collector design.

3. Explain how solar energy technologies can be integrated into a building's design. Provide students plans for a simple structure (e.g., vacation cottage, farm building, room addition). Have students modify the plans or build models showing how passive and/or active solar energy technologies can be incorporated into the design. Make sure students account for collection, storage, distribution, control, and aesthetic considerations. Discuss how using solar energy technologies is changing architecture and life styles.

4. Discuss how solar energy can be used to generate electricity for a community with solar farm or solar central receiver technology. Using common materials, have students build a working model of a solar central receiver and/or linear parabolic solar farm. Ask students to evaluate the cost, efficiency and land requirements associated with large scale solar energy systems.

5. Discuss how solar energy can be used to heat water for domestic and industrial applications. Have students design, build, and test a passive or active solar energy system to heat a given quantity of water. During the testing process, monitor the temperature of the water and calculate the heat gain in BTU's. Ask students to identify the problems associated with heating water with solar energy.

6. After introducing the greenhouse effect, have groups of students construct simple greenhouses using polyethylene plastic, staples, and wood on a site with a good solar orientation. Monitor the temperature inside the greenhouse at various times of the day for several weeks. Locate plantings both inside and outside the greenhouse and compare their development over time. Discuss how greenhouses can be used to grow plants year round and for heating living space.

7. Explain how solar radiant energy can be directly converted into electrical energy using photovoltaic technology. Using one or more photovoltaic cell(s), have students determine electrical energy produced. Using the cost of cell(s) and their energy output, have students calculate the cost of powering one 100 watt light bulb using photovoltaic technology. Discuss the cost-effectiveness of photovoltaic technology and the potential applications and impacts if they become affordable.

8. Discuss how photovoltaic technology is being used to power calculators and satellites. Have students design, build, and test a solar power device that addresses a given problem. Problems could include recharging batteries, measuring light, circulating air through a collector and powering a model vehicle. Ask students to identify other appropriate applications for photovoltaic technology.

9. Discuss the basic elements needed to harness energy from the sun (i.e., enclosure, glazing, flat black absorber surface, thermal mass, insulation). Provide students a wide variety of easy-to-use materials including things like aluminum foil, cardboard, duct tape, fiberglass insulation, glass jars, pea gravel, and polyethylene plastic. Have each student modify a shoe box or similar container so it will collect, convert, distribute, store, and control energy from the sun. Test the collectors outdoors and record the temperatures produced in the sun and maintained in shade. Evaluate the various materials and techniques used to maximize solar collector performance. Ask students to identify which designs seem to be the most useful.

10. Discuss how climate and location affect the orientation and performance of solar energy collection devices. Have students monitor energy output while experimenting with various solar altitude and azimuth angles to a given light source. Discuss how orientation and tracking techniques maximize solar collector and photovoltaic performance. Ask students to identify good and bad locations for solar energy utilization based on climate and available solar radiant energy.

11. Discuss the milestones in the history and evolution of solar energy systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

12. Discuss the career opportunities in solar energy utilization. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to solar energy utilization. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

PASSIVE SOLAR ENERGY

Introduction

Solar energy is the energy received by the earth from the sun. It is sometimes referred to as radiant (light) energy. The sun radiates energy in all directions but only about two-billionths of this reaches the earth. This small amount is equal to about as much heat and light as is available from all our known coal, gas, and oil reserves.

Solar energy is free, non-polluting, and safe. Unlike natural gas, coal, and petroleum, we cannot run out of solar energy. It is an inexhaustible energy source. It can do more than warm the earth in the summer and provide light during the day. Solar energy can be used to heat homes and commercial buildings. It can be used to generate electricity. It can even be used to power electronic devices on communication satellites.

Today, studies and tests are being done all over the world to find good ways to use solar energy. Reports have proven that the sun may become a prime source of energy in the future. Did you know that if we could convert the sun's energy at 20% efficiency, the amount of solar energy that reaches an area the size of the state of New Jersey could fill our current needs for electrical power? That fact alone makes the sun's energy an important source.

Solar energy is too valuable to overlook. At a time when fuel costs are growing and supplies are running low, a free source of energy is more attractive than ever. You do not have to pay a utility company for energy when you heat your home with solar energy. Unfortunately, the technology required to put the sun's radiant energy to useful work is very expensive. Solar homes and buildings have to be specially designed to catch the sun's energy and keep it for a long time. Their designs often require extra, and some times special, materials that increase the cost of solar buildings.

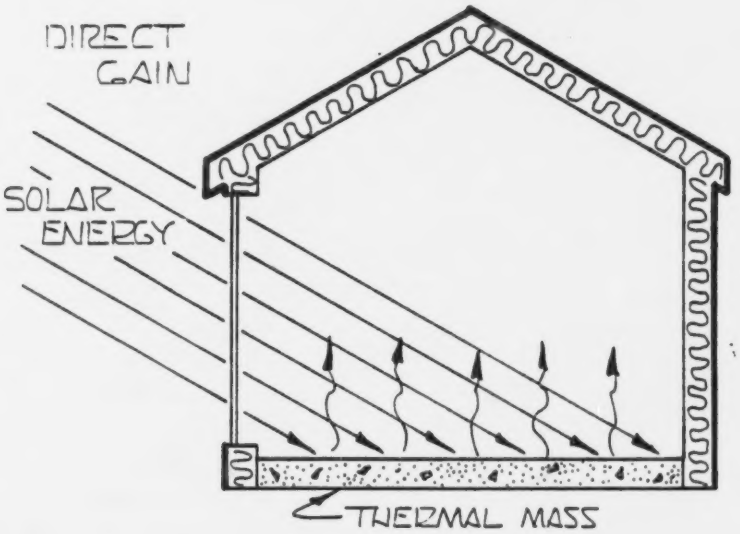
Passive solar energy technology takes advantage of the sun's radiant (light) energy for heating and cooling without dependence on energy-consuming devices like fans and pumps. Passive solar buildings are especially designed to collect, convert, store, and distribute energy from the sun.

Passive solar buildings use south-facing glass to collect solar energy. During the collection process, solar energy is in the form of light. It needs to be converted to heat. To encourage the conversion process, passive solar buildings include a lot of dark colored surfaces. These surfaces absorb the light and convert it to heat. To prevent overheating, these surfaces are often made of materials that absorb heat. These materials are often referred to as thermal mass. The two most common materials used for thermal mass are masonry (i.e., concrete, bricks, stone) and water. If the temperature inside the building drops, these materials will give up their stored heat to the building. Vents and large open spaces are used to distribute heat throughout the building. Movable insulation and shading (roof overhangs and/or trees) are often used to control the collection process.

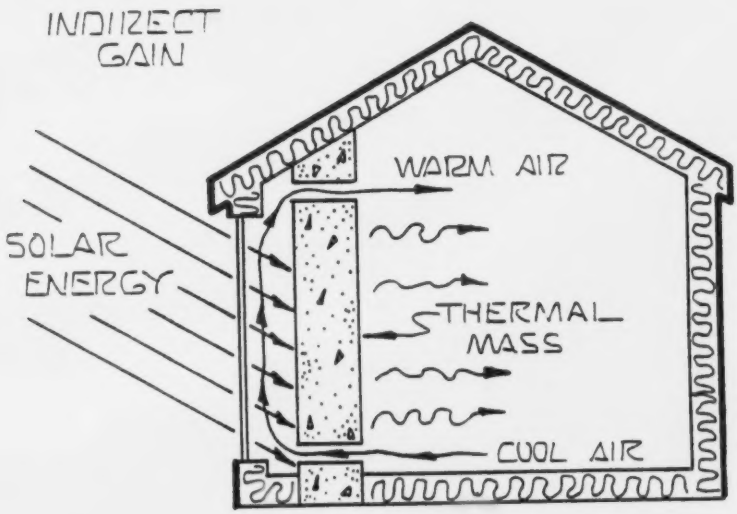
Passive solar buildings typically use one of the following techniques:

- direct gain systems
- indirect gain systems

Direct gain systems allow sunlight to enter directly into the living space through south-facing glass. The collection, conversion, storage, and distribution processes occur within the living space (see illustration below).



Indirect gain systems have a thermal mass between the south-facing glass and the living space. Sunlight passes through the glass, is converted into heat, and is absorbed by the thermal mass. For heat to enter the living space, it must pass through vents at the top and bottom of the thermal mass. In addition, heat can also enter the living space by passing through the thermal mass.



Passive solar energy systems are often used to heat living space and domestic hot water. In addition to providing heat, south-facing glass can provide a natural form of lighting.

Passive solar technology can also be used for agricultural applications. Plants can be grown all year round in passive solar greenhouses. Passive solar systems can be used to dry grain and lumber.

Solar energy is one of the most promising energy resources available to humankind. Passive solar buildings use the sun's radiant energy for lighting, heating, and cooling. They use their design, orientation, and composition to collect, convert, store, and distribute energy from the sun. Passive solar systems do not use mechanical devices like pumps or fans. There are two basic types of passive solar systems, direct and indirect gain.

Passive solar technology can also be used to heat domestic hot water, grow plants, and dry grain and lumber.

The following series of Technology Education Activities will allow students to experience passive solar energy concepts such as absorption, thermal mass and convection.

Problem Statement

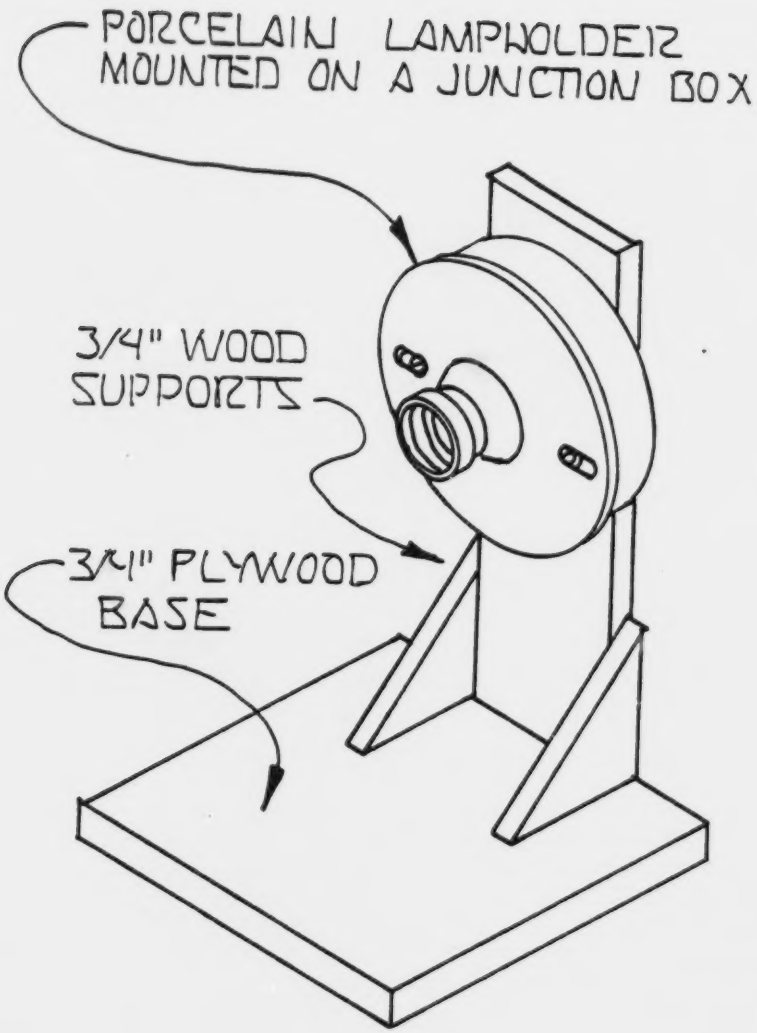
When people think about solar energy, one of the first thing that comes to mind is a house with lots of windows on the south side. The windows collect the sun's radiation and convert it to heat. During the learning activity, you will be building and testing an enclosure with glass on one side. The testing will help you discover how different things affect the temperature in a passive solar enclosure. You will probably be surprised how easy it is to harness the sun's energy.

Materials and Supplies

Each group of two or three students will need the following materials.

- Corrugated cardboard
- Utility or exacto knife
- Duct tape
- Polyethylene plastic
- Alternative light source (see DR #1)
- Ruler
- Straight edges
- 1/4" x 2" x 12" piece of hardboard
- Two thermometers
- One set of hardboard panels (1/8" x 7 1/2" x 7 1/2") painted flat black
- One set of hardboard panels (1/8" x 7 1/2" x 7 1/2") painted white or silver
- Several pieces of duct tape
- 1/2 inch rigid insulation
- Two aluminum pop cans painted flat black
- Thermal mass material (i.e., water, sand, pebbles, metal fasteners)

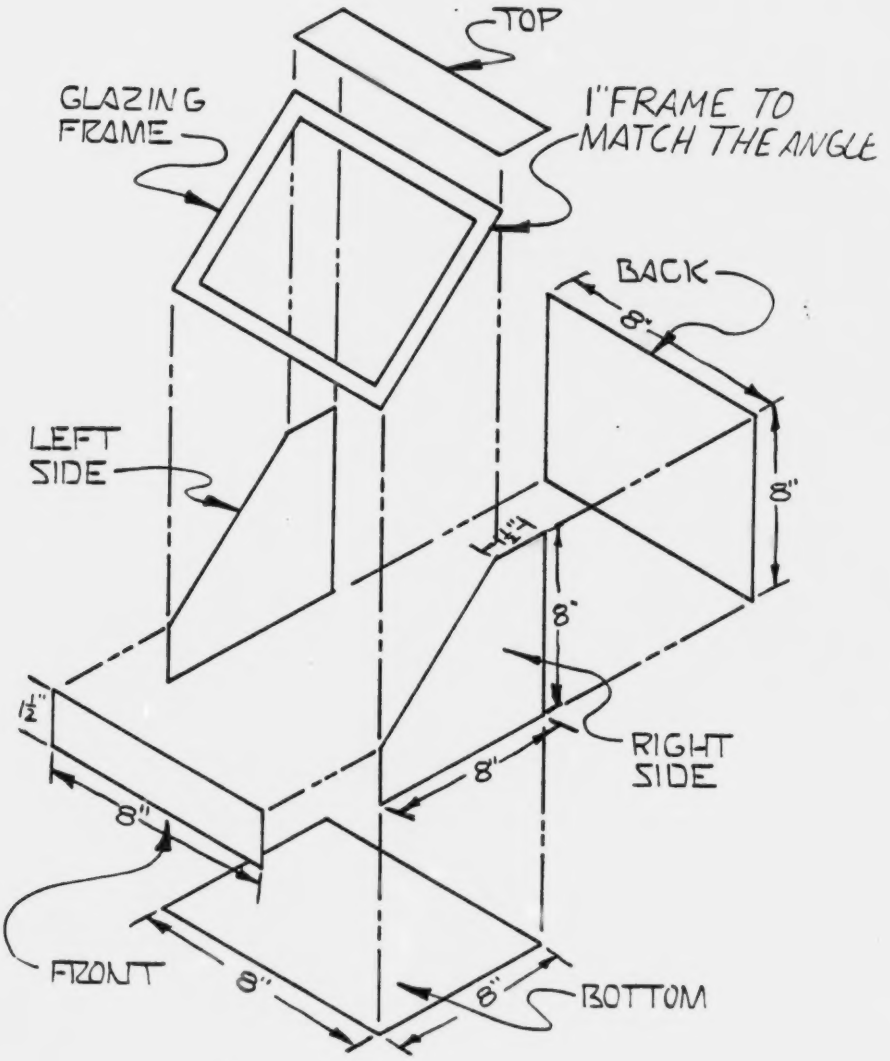
ALTERNATIVE LIGHT SOURCE



Activity Procedures

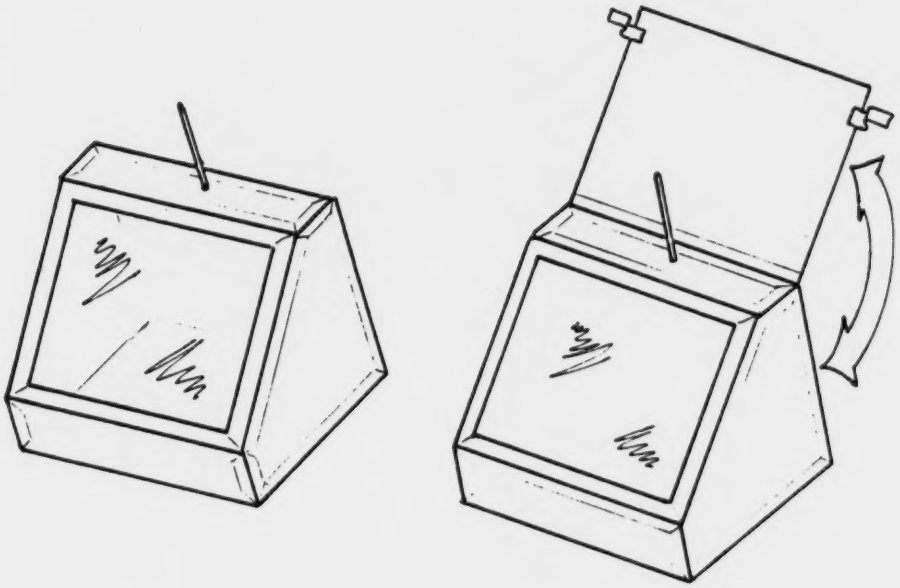
Making a Passive Solar Mockup

1. As a group, study the illustration below. Once finished, lay out the parts of the passive solar mockup on corrugated cardboard. NOTE: Templates can be made in order to make the layout process faster and more efficient.



2. Using a utility knife, cut out each piece of the passive solar mockup. Be very careful when using the utility knife. Make sure you protect the working surface under the cardboard with a piece of hardboard.

3. Once all the parts are cut out, assemble the pieces using duct tape (see illustration below). When assembling the mockup, make sure the back panel opens and closes like the one illustrated below. This means you will only need to attach its top edge to the mockup. Use several small pieces of duct tape to hold the panel closed at the bottom. When the panel needs to be opened, simply cut the two small pieces of duct tape with a razor knife, make the needed modifications, and retape the bottom two corners.

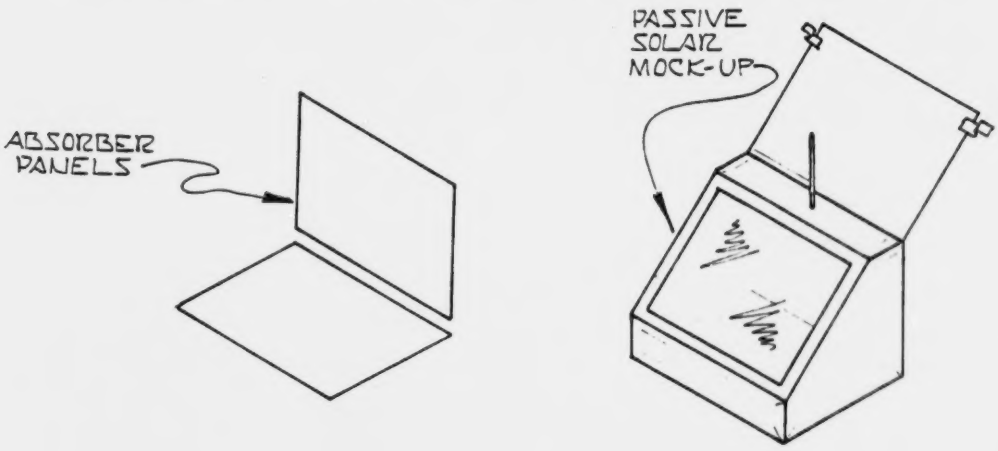


4. When all the panels of the mockup have been assembled and secured with tape, stretch a sheet of polyethylene plastic across the top face of the mockup. Cut the plastic to size, and secure all its edges with duct tape.

5. Once the polyethylene plastic has been installed, the mockup is ready to be tested.

Testing Absorber Surface Colors

1. Open the back panel of the passive solar mockup. Install one of the light colored panels across the bottom of the passive solar mockup (see illustration below). Install the other light colored panel across the back of the passive solar mockup. Use duct tape to secure the panels. Close the back panel and tape the two bottom corners.



2. Take the mockup to an outdoor site with an unobstructed orientation to the sun. Orient the passive solar mockup toward the sun for maximum heat gain. NOTE: In times of fowl weather, the alternative light source fixture can be used. Use a 115 watt miser light.

3. Install a thermometer through the top of the mockup. Make sure you can still read it easily. Be careful, thermometers break easily.

4. When the teacher tells you it is time to start, read the thermometer and record the temperature readings on the chart below. Continue reading and recording the mockup's temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: WHITE OR SILVER ABSORBER PANELS

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

5. When the teacher tells you it is time, open the back of the passive solar mockup. Remove the two light colored absorber panels. Put one of the flat black panels across the bottom of the passive solar mockup. Put the other flat black panel across the back of the passive solar mockup. Close the back panel of the mockup and tape the two corners. Make sure the passive solar mockup is still oriented toward the sun for maximum solar gain.

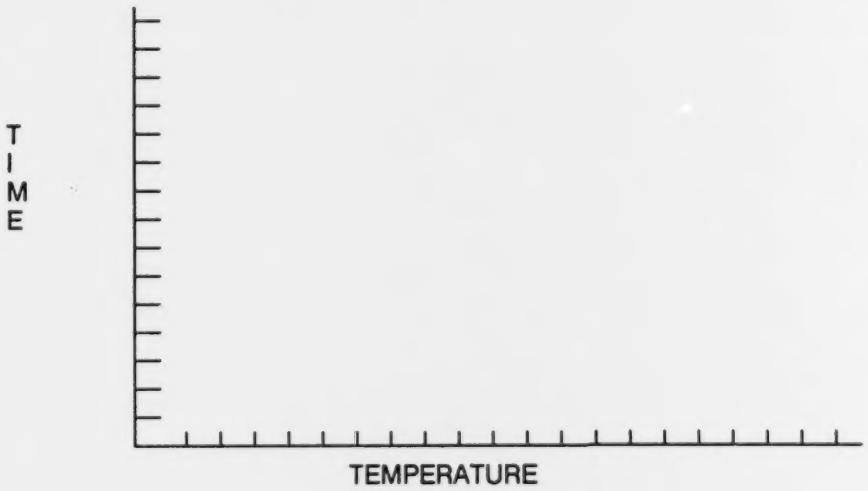
6. When the teacher tells you it is time to start, read the thermometer and record the temperatures on the chart below. Continue reading and recording the mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: FLAT BLACK ABSORBER PANEL

1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____

7. When the teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to the classroom.

8. Using the data (temperatures), draw a line graph illustrating the effect of absorber surface colors on heat gain.

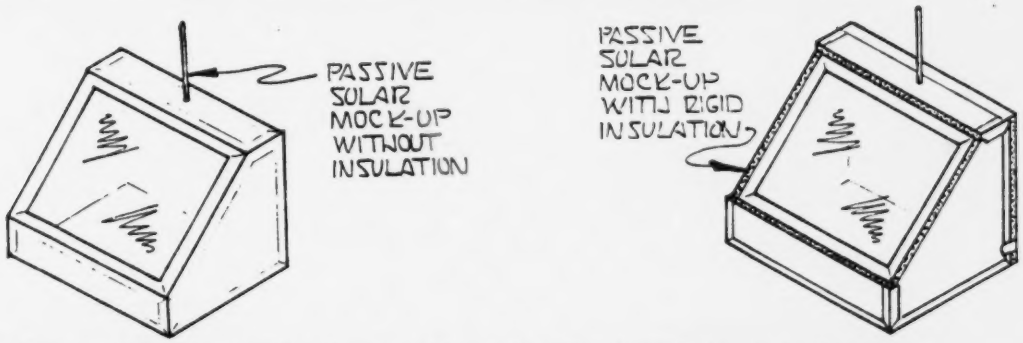


9. Heat gain with flat black absorber panels was _____ the heat gain with light colored absorber panels.

   A. less than
   B. greater than
   C. equal to

Testing the Effect of Insulation

1. Begin by laying out the parts of the passive solar mockup on rigid insulation (see illustration below). Using a utility knife, cut out each insulation panel for the passive solar mockup. Be very careful when using the utility knife. Make sure you protect the working surface underneath the insulation with a piece of hardboard.



2. Take the passive solar mockup to an outdoor site with an unobstructed orientation to the sun. Orient the passive solar mockup toward the sun for maximum solar gain. Make sure the mockup contains two flat black absorber panels. NOTE: Alternative light source can be used in place of the sun.

3. Install a thermometer through the top of the mockup. Make sure you can still read it easily. Be careful, thermometers break easily.

4. When the teacher tells you it is time to start, read the thermometer and record the temperature on the chart below. Continue reading and recording the mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: WITHOUT INSULATION

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

5. When the teacher tells you it is time, turn the solar mockup away from the sun and remove the thermometer. Using duct tape, fasten the insulation panels to the passive solar mockup (see illustration on preceding page). Insulate the front, top, back, bottom, and sides of the mockup. Do not block the window on the passive solar mockup with insulation. When you have finished, make sure the mockup's back panel will still open and close.

6. Reinstall the thermometer through the top of the mockup. Do not use the thermometer itself to punch a hole through the insulation. Make sure you can still read the thermometer easily.

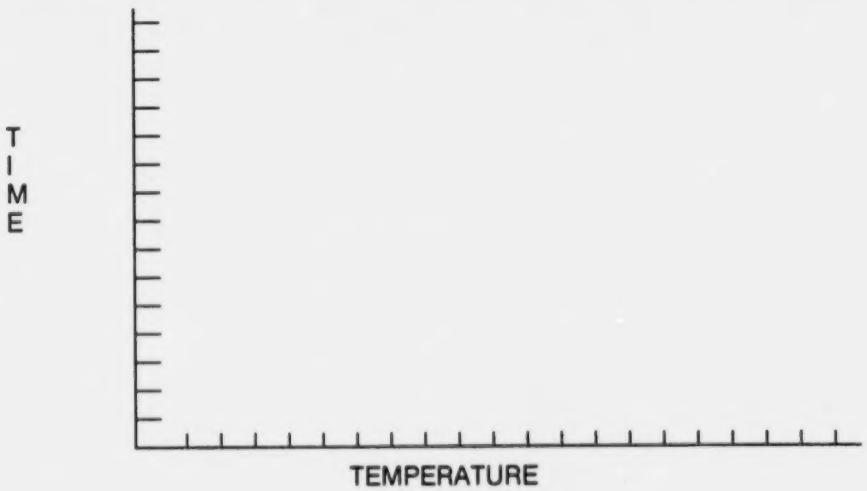
7. When the teacher tells you it is time to start, read the thermometer and record the temperature on the chart below. Continue reading and recording the mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: WITH INSULATION

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

8. When the teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to the classroom.

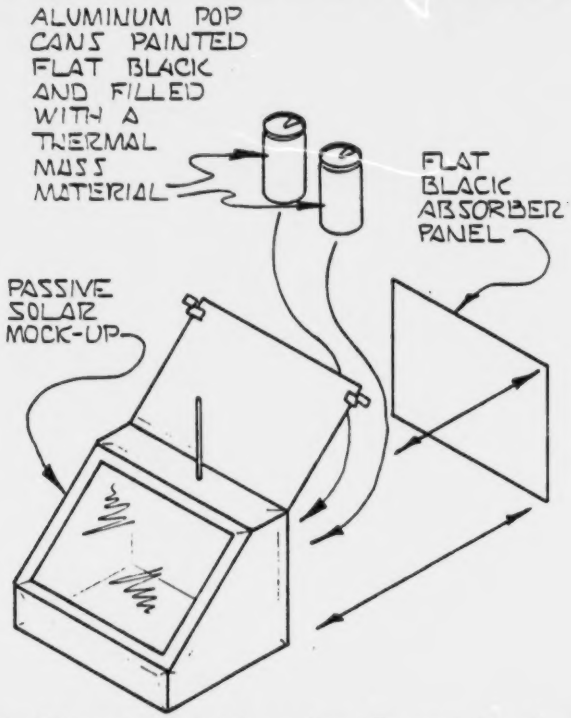
9. Using the data (temperatures), draw a line graph illustrating the effect of insulation on heat gain.



10. Heat gain with insulation was _____ the heat gain without insulation.
    A. less than
    B. greater than
    C. equal to

Testing Thermal Mass

1. Prepare two containers of thermal mass for the passive solar mockup. Fill two pop cans painted flat black with a thermal mass material (see illustration below).


ALUMINUM POP CANS PAINTED FLAT BLACK AND FILLED WITH A THERMAL MASS MATERIAL
FLAT BLACK ABSORBER PANEL
PASSIVE SOLAR MOCK-UP

2. Open the back of the passive solar mockup. Remove the absorber panel located across the back of the mockup. Place the two containers of thermal mass inside the mockup, reinstall the absorber panel across the back of the mockup. Close the back panel of the mockup and tape the two bottom corners.

3. Carefully take the passive solar mockup to an outdoor site with an unobstructed orientation to the sun. Orient the passive solar mockup toward the sun for maximum solar gain. NOTE: The alternative light source can be used (see DR #1).

4. Install a thermometer through the top of the mockup. Make sure you can still read it easily. Be careful, thermometers break easily.

5. When the teacher tells you it is time to start, read the thermometer and record the temperature on the chart on the following page. Continue reading and recording the mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: IN THE SUN

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

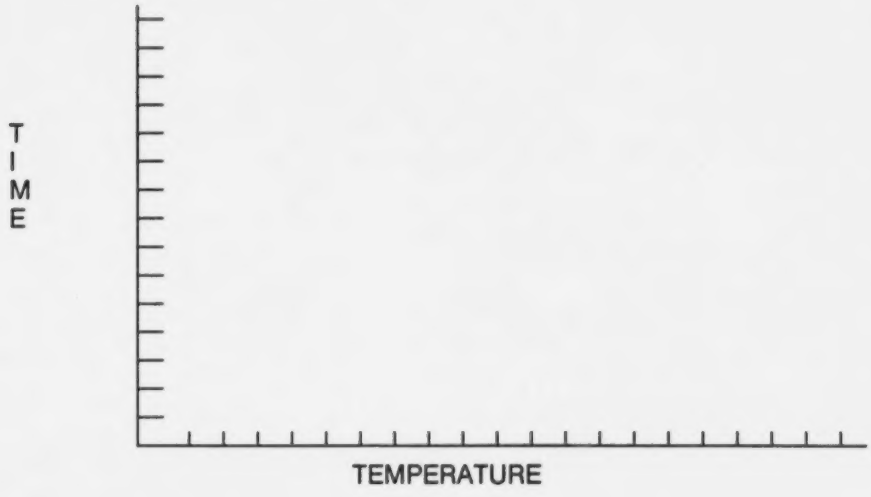
6. When the teacher tells you it is time, move the mockup out of the sun. Continue to read and record the mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: OUT OF THE SUN

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

7. When the teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to the classroom.

8. Using the data (temperatures), draw a line graph illustrating the effects of thermal mass in a passive solar energy system.

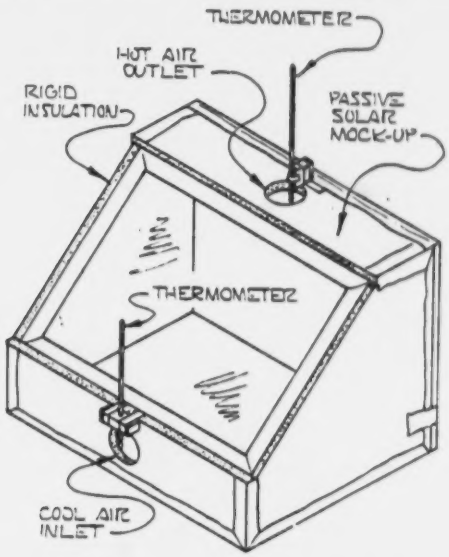


9. When the passive solar mockup containing thermal mass was moved out of the sun, its interior temperature _____

   A. increased rapidly
   B. increased slowly
   C. stayed the same
   D. decreased slowly
   E. decreased rapidly

Testing a Convection Distribution System

1. Most passive solar energy systems rely heavily on convection to distribute heat throughout a building. Convection is the transfer of heat by means of the physical movement of a gas or liquid. Since heat rises, many passive solar energy systems use vents to move heat from a collection area to a living space. These vents are typically located at the bottom and top of the collection area. Cool air enters the bottom vent, is heated, rises, and leaves through the top vent. To distribute heat through the passive solar mockup, you need to create a cool air inlet and a hot air outlet. To create the cool air inlet, cut a 2" hole in the front of the passive solar mockup (see illustration below). To create a hot air outlet, cut a 2" hole in the top of the passive solar mockup.



2. Take the passive solar mockup to an outdoor site with an unobstructed orientation to the sun. Orient the passive solar mockup toward the sun for maximum solar gain.

3. Install one of the thermometers in front of the cool air inlet (see illustration on the previous page). Install the other thermometer inside the hot air outlet. Make sure you can read both thermometers easily. Be careful when installing the thermometers as they break easily.

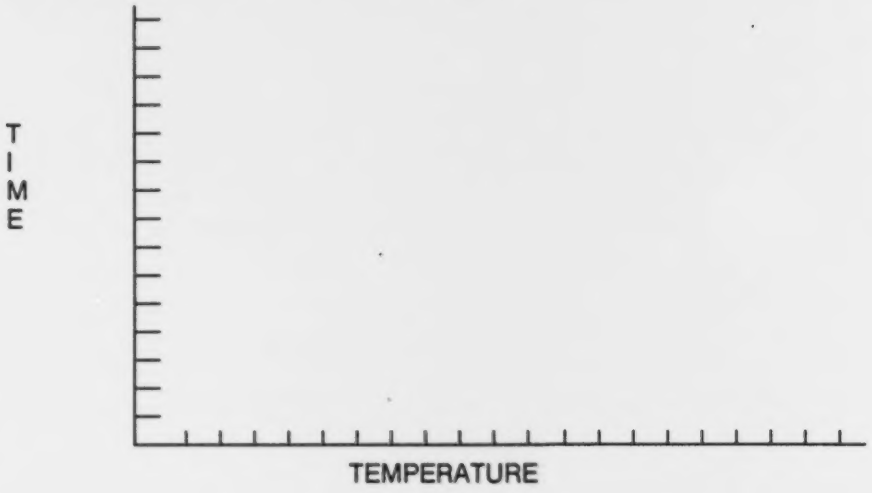
4. When the teacher tells you it is time to start, read both thermometers and record the temperatures on the chart below. Continue reading and recording the mockup's input and output temperatures every 60 seconds for 15 minutes.

TEMPERATURE READINGS: CONVECTION DISTRIBUTION

	Inlet Temperatures	Outlet Temperatures
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
6	_____	_____
7	_____	_____
8	_____	_____
9	_____	_____
10	_____	_____
11	_____	_____
12	_____	_____
13	_____	_____
14	_____	_____
15	_____	_____

5. When the teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to the classroom.

6. Using the data (temperatures), draw a line graph illustrating the input and output temperatures of the passive solar mockup.



7. Passive solar mockup output temperatures were _____ the inlet temperatures.

   A. greater than
   B. equal to
   C. less than

Activity Analysis

1. Define passive solar energy.

_____

_____

2. Explain how passive solar systems convert radial light and converts it into heat (e.g., storage, collection, convection, and distribution).

_____

_____

3. What relationship does window location have when incorporating passive solar design into architectural structures such as homes?

_____

_____

4. List two advantages of passive solar energy.

_____

_____

5. List two disadvantages of passive solar energy.

_____

_____

6. List two applications for passive solar energy.

_____

_____

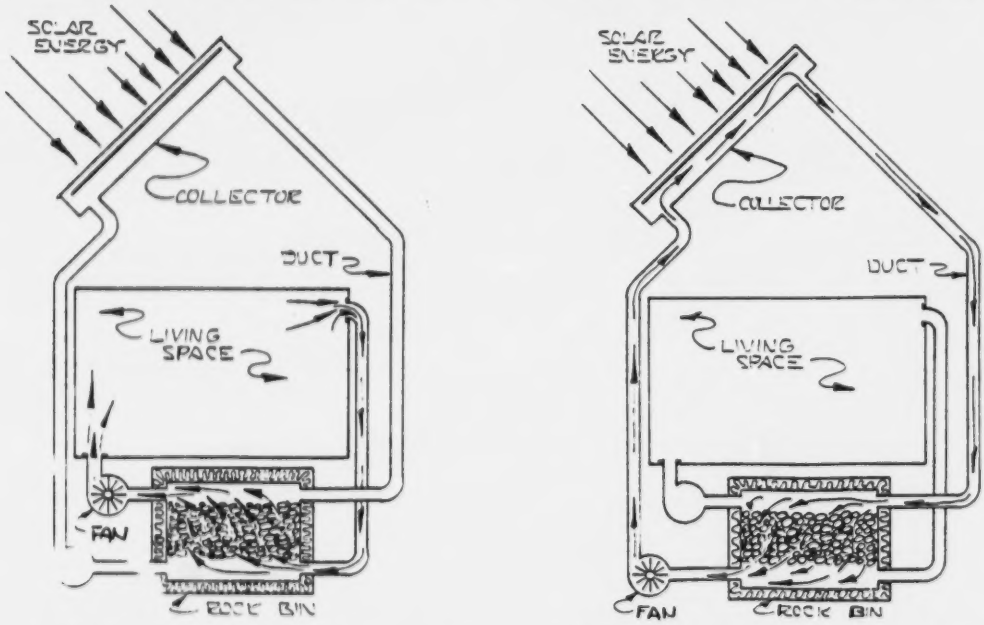
ACTIVE SOLAR ENERGY

Introduction

During the Passive Solar learning activities, you discovered the potential of collecting the sun's radiant energy. Even though the technology you used was very simple, you were able to convert solar energy to a more useful form of energy, heat. Contrary to popular beliefs, solar energy systems do not have to be complicated to work effectively.

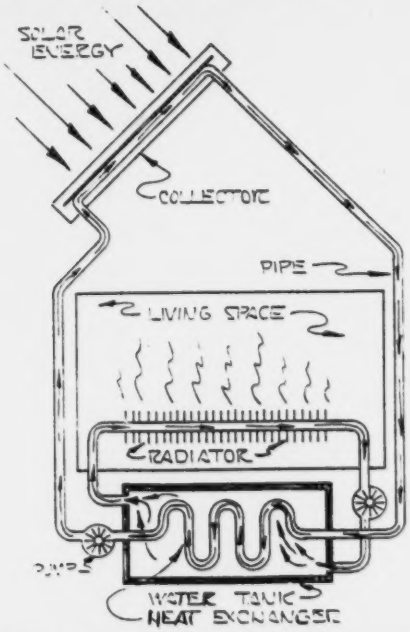
Passive solar homes and buildings use architectural features to collect, convert, store, and distribute solar energy. Active solar energy systems use collectors to collect and convert the sun's radiant energy. Unlike passive solar energy systems, active systems use mechanical and electrical devices. These devices often need electrical energy to work.

There are two basic types of active solar systems: air systems and liquid systems. Air systems use air for a heat transfer fluid. Using a fan, cold air is pumped to the solar collector (see illustration below). Once inside, it is circulated through the absorber system. When the absorber system is exposed to solar energy, it becomes very hot. As the air circulates through the absorber system, it too becomes hot. When the air leaves the collector, the heat it carries can be stored or used to heat living space. To store the heat, the air is typically circulated through a bin filled with rocks. As the air travels through the bin, the rocks absorb the heat. When solar energy is not available, room air is circulated through the bin, heated by the rocks and returned to the living space. Air systems use heating ducts and fans to distribute the heat.

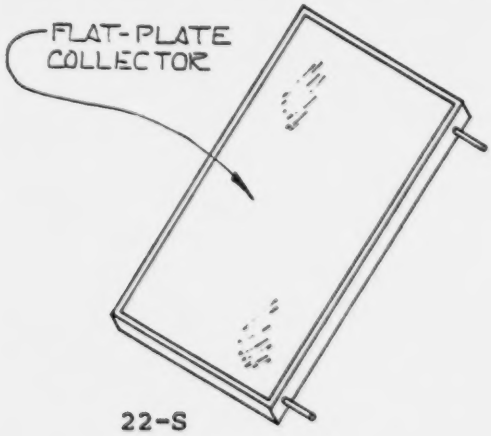


Air systems are usually simpler, cheaper, and require less maintenance than liquid systems. One major disadvantage of air systems is they are not very effective for heating water.

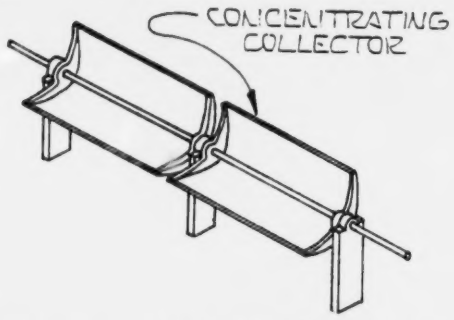
Liquid systems use water or an antifreeze solution as a heat transfer fluid (see illustration below). Like air systems, the heat transfer fluid is pumped through an absorber system where it becomes hot. After it has been heated, the heat transfer fluid can be circulated through radiators. The radiators, in turn, heat the air in the living space. Excess heat is typically stored in a tank of water. The hot water can be used for domestic purposes. Pipes and pumps are used for heat distribution. Preventing the heat transfer fluid from freezing is a major consideration when designing and installing liquid systems.



There are two basic types of solar collectors used in active solar systems. The most commonly used is a flat plate collector (see illustration below). The collector is comprised of a thin rectangular box with its top face covered with a glazing material. The glazing material can be glass or clear plastic. The rectangular box houses and insulates the absorber system. If the collector is designed for a liquid system, the absorber system is a network of pipes connected to a large sheet of metal. If the absorber system is designed for an air system, it is usually a corrugated or thin sheet of metal. In both cases, the absorber system is treated with a special flat black paint.



The second basic type of solar collector is called a concentrating collector (see illustration below). These collectors use a reflective surface to concentrate solar radiant energy onto an absorber system. These collectors can only be used in liquid systems. Because the solar energy is concentrated, these collectors can produce temperatures up to 1,000 degrees Fahrenheit. When the sun's position changes, concentrating collectors must be adjusted. This adjustment process is called tracking. To be efficient, concentrating collectors must be tracked with the sun throughout the day.



Most active solar systems require more than one collector. The collector area for a typical house can range between 1/4 and 1/3 of the floor area being heated.

The most popular application for active solar technology is heating water for domestic, industrial, and commercial use. These hot water applications range from heating swimming pools to producing steam for industrial applications. Both air and liquid systems can be used to heat residential homes. However, many experts feel that active solar heating is best suited for commercial and industrial applications. Lastly, solar energy systems can be used to provide air conditioning. However, active solar air conditioning systems are very expensive.

Active solar energy systems use collectors to convert the sun's radiant energy to useful thermal energy. Active systems use mechanical and electrical devices that require electrical energy. The two basic types of active systems are air systems and liquid systems. Air systems use ducts and fans for heat distribution, and use rocks for heat storage. Liquid systems use pipes and pumps for heat distribution, and use water for heat storage. The two basic types of solar collectors are flat plate collectors and concentrating collectors. Flat plate collectors enclose the absorber system in a rectangular box with glass on one face. Concentrating collectors use a reflective surface to concentrate solar energy onto an absorber system. Active solar systems can be used to heat water and heat and air condition living space.

Materials and Supplies

- One length of 1/2" copper pipe, 30 inches long
- Two pieces of 1 x 4 lumber, 2 feet long
- Two sheets of plywood, 3/4" thick, 8" wide, and 24" long
- One sheet of 1/8" hardboard, approximately 28" wide and 24" long
- Spray adhesive
- Flat black paint
- Enough commercial grade aluminum foil or reflective mylar (aluminized) to cover the hardboard

- Fourteen 1/2" long #6 pan head screws
- One 10 foot length of duct tape
- Paper, 12" x 24"
- Scales or rulers
- Scissors
- Drill
- DR #1
- All the parabolic collectors made by the class
- One garden hose pump that attaches to an electric drill
- Two buckets
- Two thermometers
- One C-clamp for every parabolic collector
- One 12" section of garden hose for every parabolic collector
- One portable electric drill
- One extension cord
- Several gallons of water
- Access to an outdoor receptacle
- An outdoor site with an unobstructed orientation to the sun

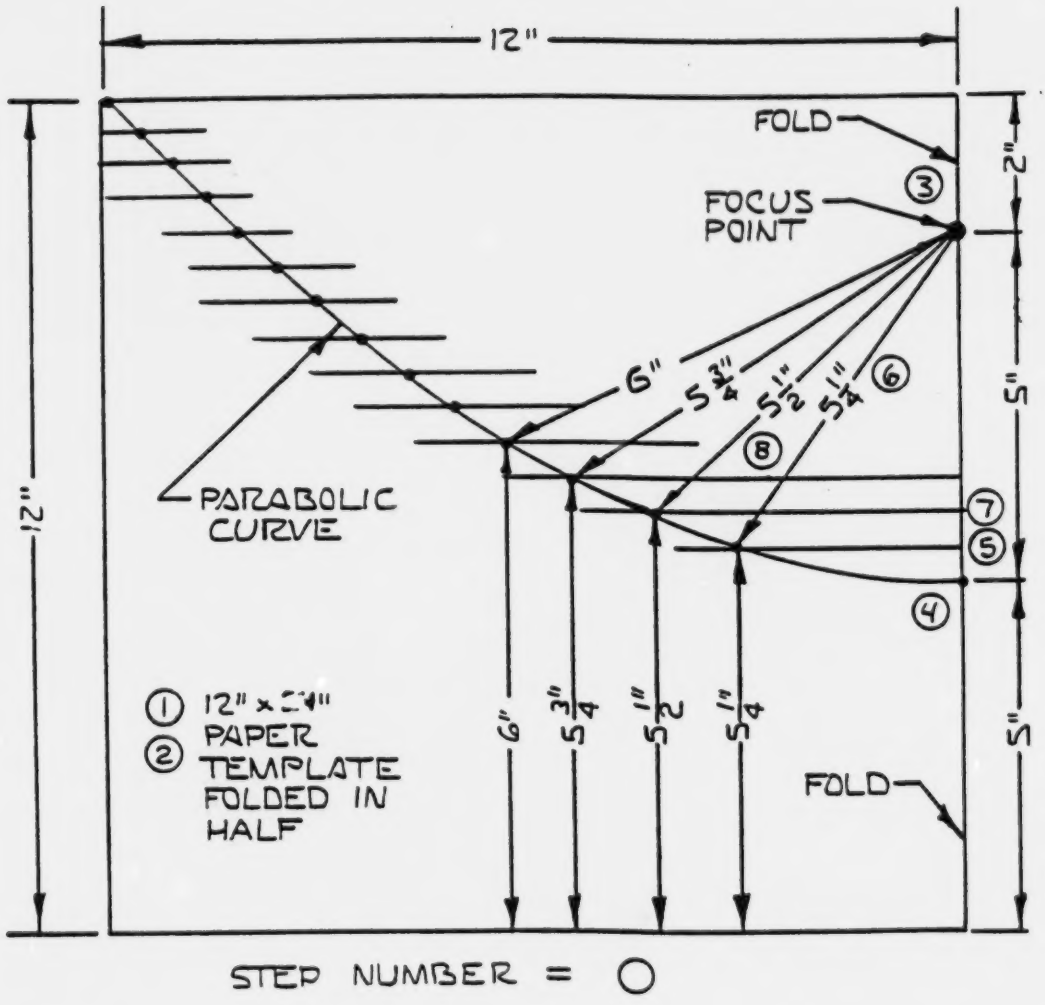
Problem Statement

Solar collectors are the most important element in an active solar system. They collect the sun's radiant energy and convert it to useful thermal energy. To use the thermal energy, a heat transfer fluid must be circulated through the collector. During the following lab activity, you will be building a simple parabolic collector. When the collector is finished, test it by linking it with other collectors and circulating water through the system. In addition, you will be collecting and interpreting input versus output temperature readings.

Making a Parabolic Collector Template

1. Cut out a sheet of paper, 12" wide and 24" long.
2. Fold the sheet of paper in half so it is 12" by 12".
3. Locate the focus point 2" from the top of the paper along the fold.
4. Locate a second point 5" from the focus point along the fold.
5. Measure and locate a point 5 1/4" from the bottom of the paper along the fold. Draw a line at a right angle with the fold from the point.
6. Measure and locate a point 5 1/4" from the focus point on the line.
7. Measure and locate a point 5 1/2" from the bottom of the paper along the fold. Draw a line at a right angle with the fold from the point.
8. Measure and locate a point 5 1/2" from the focus point on the line.
9. Continue this process of laying out points in 1/4" increments until you have reached the top of the paper.
10. When all the points have been laid out, use an irregular curve and pencil to connect the points.
11. Using a pair of scissors, cut along the line.

MAKING A PARABOLIC TEMPLATE

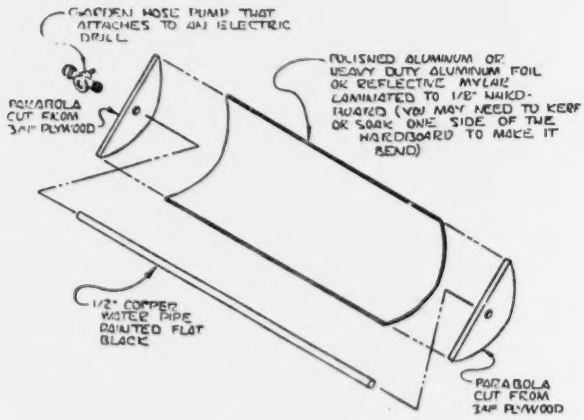


Building a Parabolic Solar Collector

1. Using the template, lay out a parabolic curve and its focal point on both sheets of plywood. Using the band saw, cut along the outside of the parabolic curve. Using a drill press equipped with the appropriate drill bit, drill a hole through the focal point on each sheet of plywood. Make sure you follow all the safety rules when using power machines.

2. Glue aluminum foil to the piece of hardboard. Before using any glue, cover the working surface with newspaper. Position the hardboard and several strips of aluminum foil on the newspaper. Apply a thin coat of adhesive to the top of the hardboard and to the back of the aluminum foil. Allow the glue to dry. When the glue is dry, position one strip of aluminum foil over the top of the hardboard so the glued surfaces are facing each other. Allow one corner of the aluminum foil to touch the hardboard. Press the two materials together. Gradually allow more aluminum foil to come in contact with the hardboard. Continue pressing the two materials together until one complete sheet of aluminum foil has been laminated to the hardboard. Repeat this process with additional sheets of aluminum foil until the hardboard is completely covered with the reflective material. Trim the excess aluminum foil around the hardboard. Tape the edges of the hardboard with duct tape.

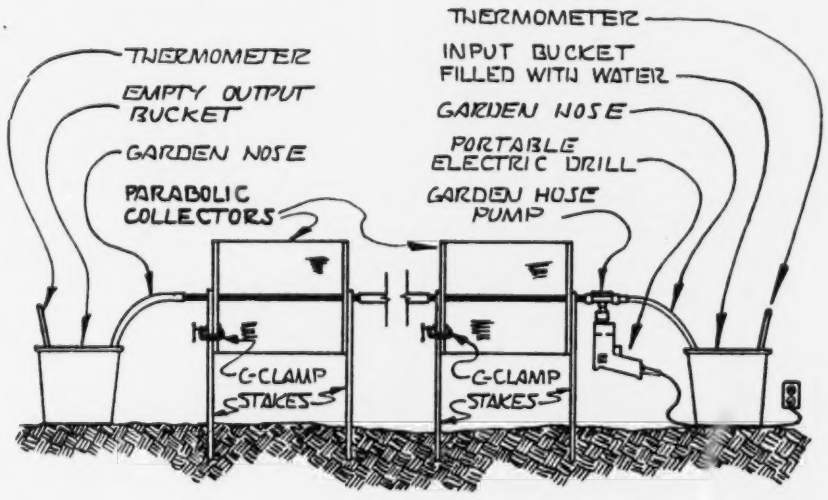
3. Assemble the collector (see illustration below). Position the edges of the hardboard on top of the two parabolic ribs. Starting in the center, drive a screw through the center of the hardboard edge to the center of the parabolic curve at each end of the collector. Once the center has been fastened, bend the hardboard around the parabolic ribs. Insert a screw every three to four inches along the parabolic curves until you have a parabolic trough.


GARDEN HOSE PUMP THAT ATTACHES TO AN ELECTRIC DRILL
POLISHED ALUMINUM OR HEAVY DUTY ALUMINUM FOIL OR REFLECTIVE MYLAR LAMINATED TO 1/8" HARD-BOARD (YOU MAY NEED TO KERF OR SOAK ONE SIDE OF THE HARDBOARD TO MAKE IT BEND)
PARABOLA CUT FROM 3/4" PLYWOOD
1/2" COPPER WATER PIPE PAINTED FLAT BLACK
PARABOLA CUT FROM 3/4" PLYWOOD

4. Prepare the absorber system by painting the copper tubing flat black. After the paint dries, insert the flat black pipe through the holes in the parabolic ribs. Drill a hole near the end of each 1 X 4 stake. Slip a stake over each end of the parabolic collector. You are now ready to set up and test the parabolic collector.

Setting Up and Testing an Active Solar System

Review the Active Solar Lab Sheet that follows. Read the problem carefully, read the research questions, complete the hypothesis section, and set up the experiment as illustrated on below. Conduct the experiment according to the procedures provided and report the findings. When you have finished, clean up the test site according to the teacher's instructions.



ACTIVE SOLAR LAB SHEET

The Problem:

Given the questionable future of fossil fuel resources, solar energy has become a viable alternative energy source. Solar energy is free. However, the technology required to harness the sun's radiant energy is expensive. Only a small percentage of the population can afford commercially available active solar systems. Even the most basic retrofit systems cost thousands of dollars more than conventional heating systems. There is a need to develop affordable and appropriate solar energy technology that the average homeowner can utilize. Therefore, the challenge is to develop and test an affordable solar collectors that the average do-it-yourselfer could build. Based on the experience, determine if the average handyperson could utilize this appropriate technology for heating living space and/or water.

Questions

1. Do active solar systems have to be "high tech" to work effectively?
2. What effect does increasing or decreasing the speed of the fluid circulating through a collector have on its output temperature?
3. What are the advantages and disadvantages of the collector in comparison to those collectors developed and tested?

Hypothesis:

1. Which of the following do you believe will prove to be true?

   A. In order for a solar collector to be effective, it must be made out of special materials.
   B. Active solar collectors are too complicated for the average handyperson to build and use on their home.
   C. Solar collectors can be made out of common everyday materials and are easy to make.

2. If you increase the speed of a fluid (air or water) circulating through a solar collector, the fluid's output temperature will _____.

   A. decrease
   B. increase
   C. stay the same

Procedures:

1. Make sure the collector is made according to the plan and the teacher's instructions.

2. Once outdoors, set up and orient the solar collector as illustrated on the preceding page. Orient the collector toward the sun for maximum solar gain. Be sure to position the thermometer in the input and output buckets.

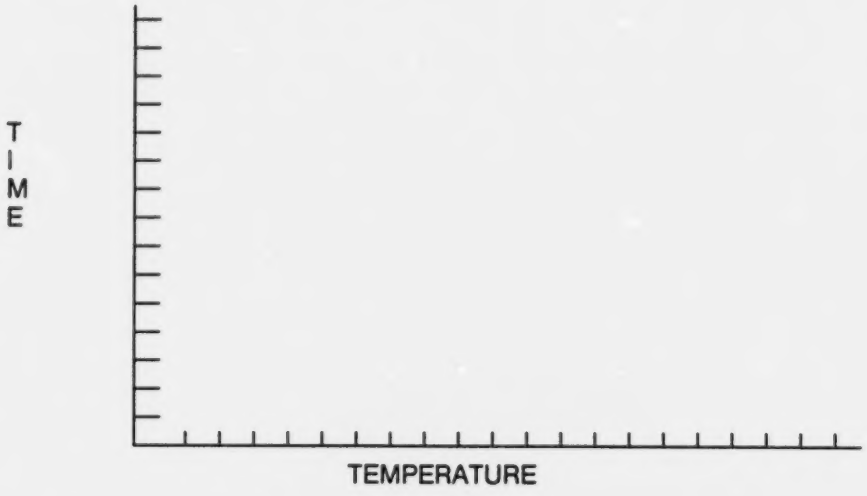
3. Ask the teacher to inspect the system and give you permission to test.

4. Read and record the temperature of input fluid. Start pumping the fluid through the collector at a rapid and even rate. Read and record the fluid's output temperature. Read and record the fluid's input and output temperatures every 60 seconds for five minutes.

TEMPERATURE READINGS (FAST)

Input Temperature	Output Temperature
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____

5. Using the temperature data collected, draw a line graph illustrating the input and output temperatures of the parabolic collector.

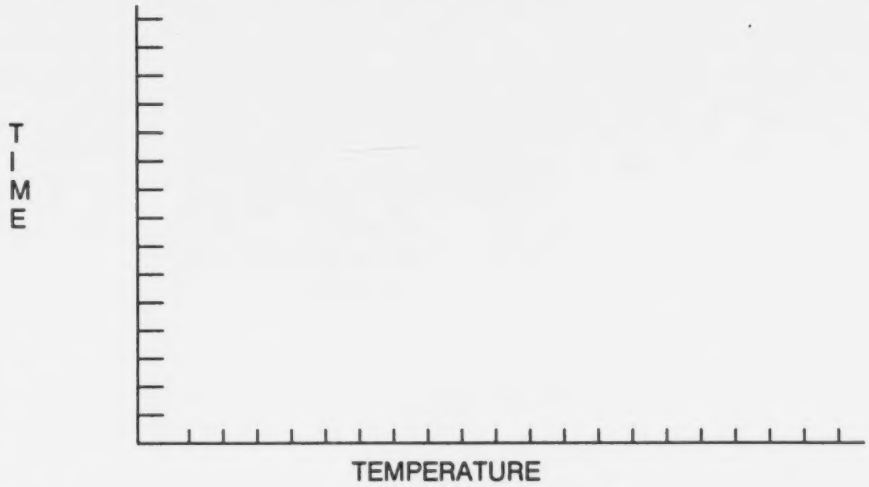


6. Refill the input bucket if needed. Read and record the temperature of the input fluid. This time, pump the fluid through the collector at a slow and even rate. Read and record the fluid's output temperature. Continue reading and recording the fluid's input and output temperatures every 60 seconds until the teacher tells you it is time to stop.

TEMPERATURE READINGS (SLOW)

Input Temperature	Output Temperature
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____
6. _____	6. _____
7. _____	7. _____
8. _____	8. _____
9. _____	9. _____
10. _____	10. _____
11. _____	11. _____
12. _____	12. _____
13. _____	13. _____
14. _____	14. _____
15. _____	15. _____

7. Using the data (temperatures) collected, draw a line graph illustrating the input and output temperatures of the parabolic collector.



8. When the teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to the classroom.

Activity Analysis

In teams, discuss how the collector performed and answer the following questions.

1. Do solar collectors have to be high tech to convert radiant energy into useful thermal (heat energy)? Support your answer with evidence from the research and development activities.

_____

_____

2. What effect does increasing or decreasing the speed the fluid is circulating through the collector have on its output temperature? Explain your conclusion.

_____

_____

3. What are two of the advantages of the collector design?

_____ _____

4. What are two of the disadvantages of the collector design?

_____ _____

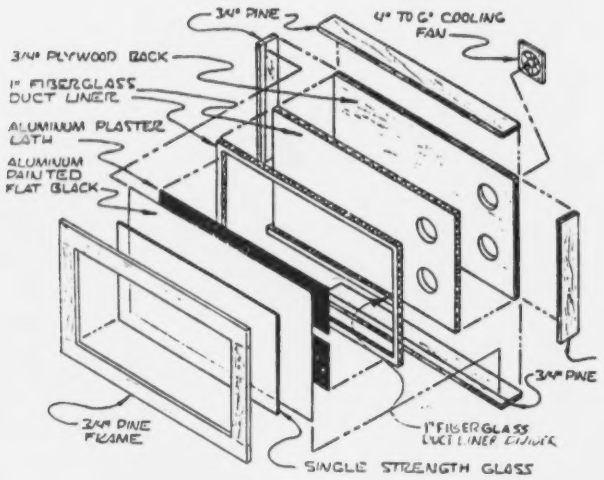
FLAT PLATE COLLECTOR (AIR)

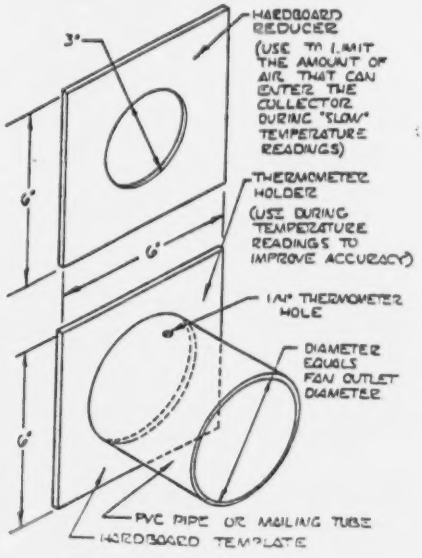
Materials and Supplies

- 1 sheet of plywood, 3/4" thick, 22 1/2" wide, and 40 1/2" long
- 2 strips of plywood or pine, 3/4" thick, 3 3/4" wide, and 42" long
- 2 strips of plywood or pine, 3/4" thick, 3 3/4" wide, and 24" long
- 2 pieces of pine, 3/4" thick, 2 1/2" wide, and 42" long
- 2 pieces of pine, 3/4" thick, 2 1/2" wide, and 17" long
- 1 sheet of single strength glass, 20" wide and 38" long
- 1 sheet of 1" fiberglass duct liner (insulation), 22 1/2" wide and 40 1/2" long
- 2 strips of 1" fiberglass duct liner, 1" wide and 40 1/2" long
- 3 strips of 1" fiberglass duct liner, 1" wide and 20 1/2" long
- 1 sheet of aluminum, 23" wide and 41" long
- 2 strips of aluminum plaster lath, 10" wide and 40" long
- 1 tube of silicone caulking
- White glue and 4D finishing nails
- Flat black paint
- 1 3" or 4" cooling fan (120 VAC)
- Extension cord
- 2 thermometers

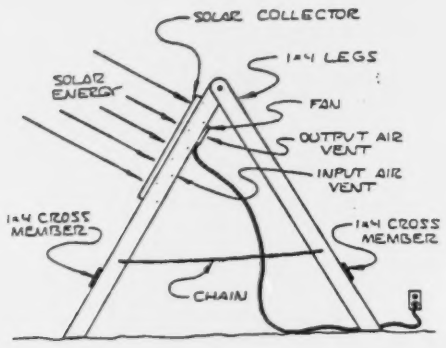
Activity Procedures

1. If this is the first time this activity has been done, then use the dimensions listed in the materials and supplies section and the illustration below to construct an active solar air flat plate collector. Be sure to obtain permission before using any pieces of power equipment.





2. Construct a collector stand using the dimensions provided in the Materials and Supplies section. Attach the collection unit to the stand (see illustration below).



3. Set up and orient the solar collector outside as illustrated in the plan above. Orient the collector toward the sun for maximum solar gain.

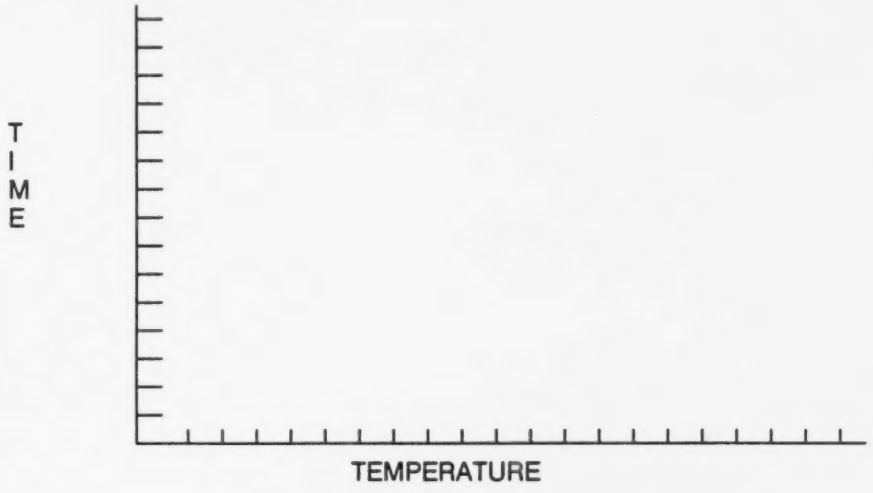
4. Attach the thermometer to the collector. The thermometer should be placed on the lower hole on the back of the collector. Attach the fan to the top hole on the back.

5. Plug in the fan and ask the teacher to inspect the system.

6. Before testing, use a second thermometer to determine the temperature outside the collector. What is the temperature? _____

7. Begin pumping the fluid (air via fan) through the collector at a fast and even rate. Read and record the fluid's output temperature. Read and record the fluid's output temperatures every 60 seconds for ten minutes.

8. Using the data (temperatures) collected, draw a line graph illustrating the output temperature of the air flat plate collector.

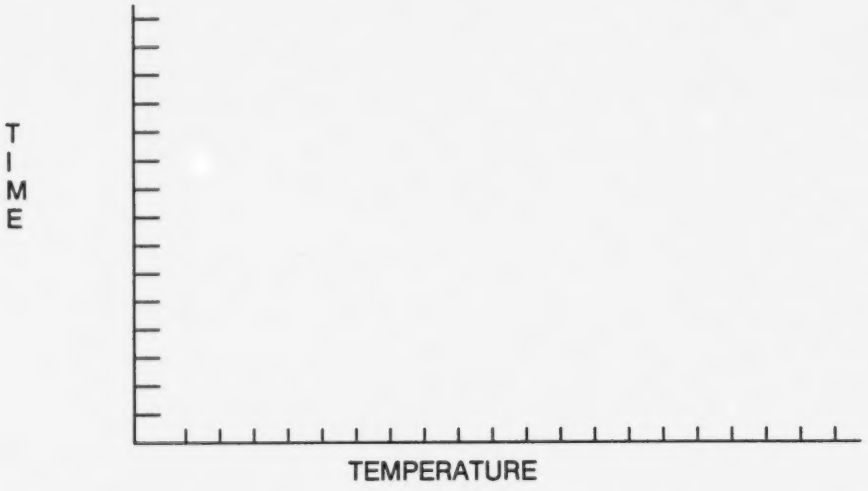


TEMPERATURE READINGS (FAST)

Output Temperature	
1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____

9. Read and record the temperature of the input fluid. This time, pump the fluid (air) through the collector at a slow and even rate. Read and record the fluid's output temperature. Continue reading and recording the fluid's output temperatures every 60 seconds until the teacher tells you it is time to stop.

10. Using the data collection, draw a line graph illustrating the output temperature of the air flat plate collector.



11. Compare the two graphs.

12. When finished clean up the site and return to the classroom.

Activity Analysis

In teams, discuss how the collector performed and answer the following questions.

1. Do solar collectors have to be high tech to convert radiant energy into useful thermal (heat) energy? Support the answer with evidence from the research and development activities.

_____

_____

2. What effect does increasing or decreasing the speed the fluid is circulating through the collector have on its output temperature? Explain your conclusion?

_____

_____

3. What are two of the advantages of the collector design?

_____

_____

4. What are two of the disadvantages of the collector design?

_____

_____

5. In your opinion, is this type of active solar collector best suited for heating living space or heating water? Explain your answer.

_____

_____

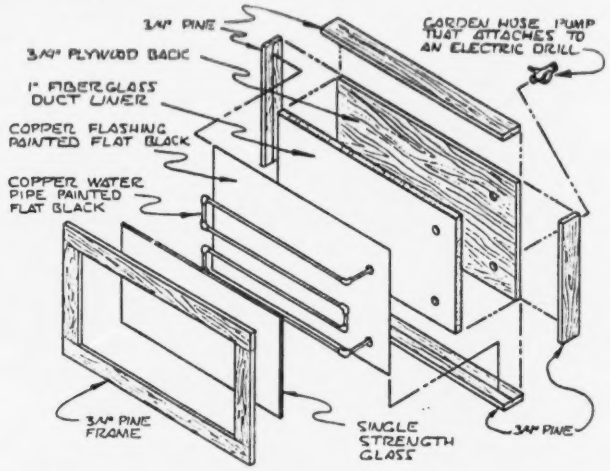
FLUID FLAT PLATE COLLECTOR

Materials and Supplies

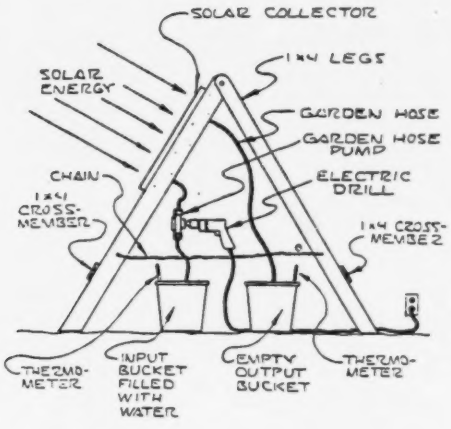
- 1 sheet of plywood, 3/4" thick, 22 1/2" wide, and 40 1/2" long
- 2 strips of plywood or pine, 3/4" thick, 3 3/4" wide, and 42" long
- 2 strips of plywood or pine, 3/4" thick, 3 3/4" wide, and 24" long
- 2 pieces of pine, 3/4" thick, 2 1/2" wide, and 42" long
- 2 pieces of pine, 3/4" thick, 2 1/2" wide, and 17" long
- 1 sheet of single strength glass, 20" wide and 38" long
- 1 sheet of 1" fiberglass duct liner (insulation), 22 1/2" wide and 40 1/2" long
- 1 sheet of copper flashing, 23" wide and 41" long
- 2 thermometers
- 4 pieces of 1/2" copper pipe, 36" long
- 2 pieces of 1/2" copper pipe, 12" long
- 8 pieces of 1/2" copper pipe, 3" long
- 8 1/2" copper elbows
- solder and flux
- 1 tube of silicone caulking
- White glue and 4D finishing nails
- Flat black paint
- 1 garden hose pump that fits on to an electric drill
- 2 large buckets
- 1 portable variable speed electric drill
- Extension cord

Activity Procedures

1. If this is the first time this activity is being done, then use the dimensions listed in the materials and supplies section and the illustration below to construct an active solar fluid flat plate collector. Be sure to obtain the instructor's permission before using any pieces of power equipment.


3/4" PINE
3/4" PLYWOOD BACK
1" FIBERGLASS DUCT LINER
COPPER FLASHING PAINTED FLAT BLACK
COPPER WATER PIPE PAINTED FLAT BLACK
GARDEN HOSE PUMP THAT ATTACHES TO AN ELECTRIC DRILL
3/4" PINE FRAME
SINGLE STRENGTH GLASS
3/4" PINE

2. When finished assembling the collector, construct a collector stand. Using the dimensions in the materials and supplies section and the illustration below, construct the collector stand.



3. Set up and orient the solar collector as illustrated in the plan above. Orient the collector toward the sun for maximum solar gain.

4. Once the collector is in place, position two thermometers in the buckets as illustrated above.

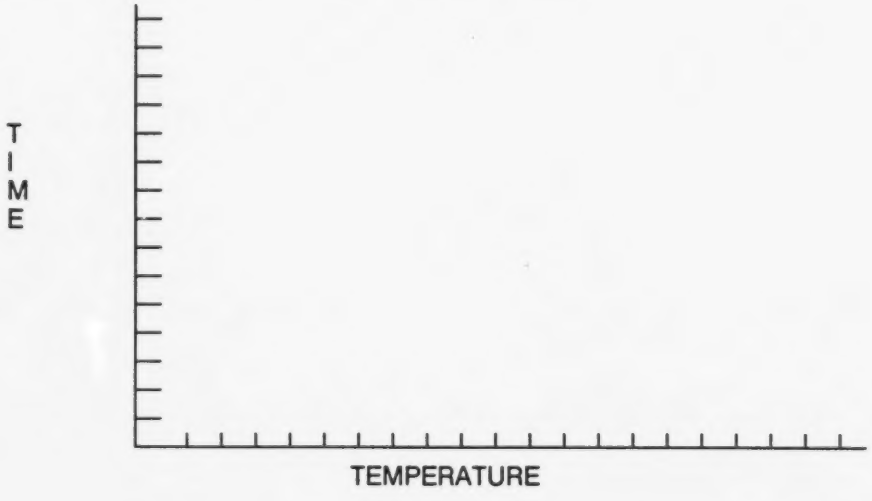
5. When you have finished setting up the collector, ask the teacher to inspect the system.

6. After the teacher gives your team the okay to start, read and record the temperature of the input fluid. Using the drill pump, begin pumping the fluid through the collector at a fast and even rate. Read and record the fluid's output temperature every 60 seconds for ten minutes.

TEMPERATURE READINGS (FAST)

Input Temperature	Output Temperature
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____
6. _____	6. _____
7. _____	7. _____
8. _____	8. _____
9. _____	9. _____
10. _____	10. _____

7. Using the data (temperatures) collected, draw a line graph illustrating the input and output temperatures of the fluid flat plate collector.

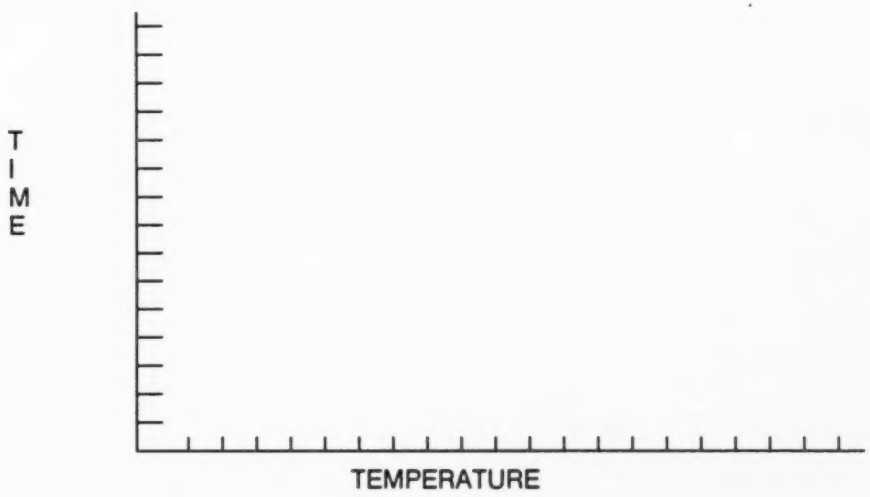


8. Refill the input bucket if needed. Read and record the temperature of the input fluid. This time, pump the fluid through the collector at a slow and even rate. Read and record the fluid's input and output temperatures every 60 seconds for fifteen minutes.

TEMPERATURE READINGS (SLOW)

Input Temperature	Output Temperature
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____
6. _____	6. _____
7. _____	7. _____
8. _____	8. _____
9. _____	9. _____
10. _____	10. _____
11. _____	11. _____
12. _____	12. _____
13. _____	13. _____
14. _____	14. _____
15. _____	15. _____

9. Using the data collected, draw a line graph illustrating the input and output temperature of the fluid flat plate collector.



10. Compare the two graphs

11. When finished, clean up the site and return to the classroom.

Activity Analysis

In teams, discuss how the collector performed and answer the following questions.

1. Do solar collectors have to be high tech to convert radiant energy into useful thermal (heat) energy? Support your answer with evidence from the research and development activities.

_____

_____

2. What effect does increasing or decreasing the speed the fluid is circulating through the collector have on its output temperature? Explain your conclusion?

_____

_____

3. What are two of the advantages of the collector design?

_____

_____

4. What are two of the disadvantages of the collector design?

_____

_____

5. In your opinion, is this type of active solar collector best suited for heating living space or heating water? Explain your answer.

_____

_____

PHOTOVOLTAICS

Introduction

Photovoltaics convert radiant (light) energy into electrical energy. The word, photovoltaic, comes from the word photo (light) and voltaic (generate electricity). Photovoltaic cells are made of two thin layers of silicon crystal. Each layer is specially treated to give it different electrical characteristics. When the photovoltaic cell is exposed to light, electrons flow from the negatively charged silicon layer to the positively charged silicon layer.

Unlike batteries and generators, photovoltaic cells have only been available since the mid 1950s. Recent innovations in photovoltaic technology have made them more affordable and efficient. They are used to power small electronic devices, generate electricity in remote areas, provide electricity for energy-efficient homes, recharge batteries, and power electronic equipment on board satellites. They have even been used to power experimental vehicles including General Motors' solar powered automobile, the Sunraycer, and DuPont's solar powered airplane, the Solar Challenger.

Photovoltaics are a clean, and often portable form of energy utilization technology. Unfortunately, they are still too expensive for large scale energy conversion applications.

Materials and Supplies

- Silicon solar cells (Radio Shack CAT NO. 276-138 or 276-124 or equivalent) You will need to produce at least 2 VDC.
- One light emitting diode (LED)
- One panel DC volt meter (Radio Shack CAT NO. 270-1754 or equivalent)
- Three feet of 18 gauge wire
- Two pieces of wood, 3/4" x 3" x 8"
- Two pieces of wood, 3/4" x 3" x 10 1/2"
- One piece of plexiglass, 1/8" x 7" x 11"
- One piece of hardboard, 1/8" x 7" x 11"
- One piece of plywood, 3/4" x 8" x 8"
- One piece of wood, 3/4" x 2 1/2" x 8"
- Two triangular pieces of wood, 3/4" x 4" x 4"
- One octagon shaped electrical box,
- One porcelain light fixture
- One 150 watt spot light bulb
- One 36" length of 3 wire service cord
- One electrical plug

Activity Procedures

1. Using the illustration as a guide, mount the panel meter to the plexiglass panel. Make sure to leave enough room for the light emitting diode (LED) and photovoltaic cells.

2. Drill a hole the same size as the LED just above the meter movement. Install the LED through the hole from the back of the plexiglass panel. Secure the LED with a small drop of glue if necessary.

3. Using the illustration as a guide, lay out the photovoltaic cells on the back of the plexiglass panel. Once they are in position, fasten them to the plexiglass with transparent tape.

4. Using the schematic as a guide, wire the photovoltaic cells in series and connect the wires to the LED. Remember the short lead on the LED is negative. Wire the voltmeter in parallel with the LED.

5. Since photovoltaic cells are expensive and delicate, make an enclosure to house them.

6. Before final assembly, drill three large holes at the bottom and the top of the hardboard panel. This will allow cool air to circulate through the enclosure.

7. Using the illustration as a guide, assemble the light source. Make sure the electrical box is grounded.

Activity Analysis

Introduce students to the basic forms of energy (i.e., radiant, mechanical, thermal, chemical, electrical). Explain how energy can be neither created nor destroyed and discuss how energy can be converted from one form to another. Position the lamp at least two feet away from the photovoltaic panel. During a class demonstration or laboratory activity, have students answer the following questions.

1. When the lamp is on, what role is it playing in an photovoltaic energy conversion system?

2. What form of energy is being produced by the lamp?

3. With the lamp on, how many volts are being produced by the photovoltaic cells?

4. What form of energy is being produced by the photovoltaic cells?

5. What effect do clouds have on the energy conversion process (Hint: Position a piece of paper between the lamp and the photovoltaic panel)?

6. Are photovoltaics an efficient or inefficient energy conversion device (Hint: Compare the amount of light produced by the lamp with the amount of light produced by the LED)?

7. Using the formula below, what is the cost per watt of using this technology based on the voltage and current ratings for one photovoltaic cell?

$$\frac{\text{Cost of one cell}}{\text{Voltage Rating} \times \text{Current Rating}} = \text{Cost Per Watt}$$

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USING ALTERNATE ENERGY SOURCES

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ALTERNATE ENERGY SYSTEMS

Suggested Learning Objectives

Upon completion of the Alternate Energy unit, students will be able to:

A. Define and properly use common alternate energy **terminology** like turbine, inverter, geothermal fracturing, vertical axis, pyrolysis, and anaerobic. SC1

B. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with alternate energy systems (e.g., storage batteries, geothermal deposits, capital).

C. Identify and evaluate **career** opportunities associated with alternate energy systems (e.g., civil engineer, wind generator technician, farmer) based on their interests, talents, and career expectations.

D. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when using alternate energy systems. PH3

E. Describe the environmental and societal **impacts** associated with various alternate energy systems including visual pollution, decentralization of energy resources, conservation of fossil fuels, land utilization, and higher energy costs. SC2

F. Identify basic **applications** for alternate energy systems including heating living space, generating electricity, and producing alternate fuels for transportation systems. SC1

G. Summarize the major milestones in the **history** and evolution of alternate energy technologies including the utilization of wind energy by the Dutch in the 1600's, the building of Hoover Dam, and the introduction of gasohol. SS2

H. Describe the harnessing, conversion, storage, control, and distribution **processes** used in wind, geothermal, ocean thermal, tide, wave, hydroelectric, ocean current, nuclear and biomass energy systems. SC1

I. Design, build, test and present working models of alternate energy systems like wind generators, hydroelectric turbine/generator, and geothermal power plant.

J. Select and present the best alternate energy system for a given problem based on geographic, societal, environmental, monetary, safety, and technological consideration. SC2

K. Determine the amount of energy produced by an alternate energy system using appropriate measuring tools and units. SC4

L. Forecast what the world will be like when fossil fuel energy resources become too expensive to use at the current rate. SC2

M. Evaluate relationship between the need to utilize alternate energy resources and the need to preserve our natural resources. SC2

N. Assess the cost-effectiveness of using a given alternate energy resource based on a given timeframe, current energy cost, the cost of implementing an alternate energy system, and the amount of energy produced.

O. Select and defend the optimum alternate energy technology to supplement the energy needs of a household, enterprise or community.

P. Forecast the potential effects of alternate energy systems on fossil fuel utilization, energy costs, pollution, and lifestyles. SC2

Suggested Learning Activities

1. Explain how waste products like garbage, manure, and crop residue can be processed into biofuels. During a laboratory activity, have students process old newspapers into fireplace logs by soaking them in water, rolling them into tight logs, securing them with wire, and allowing them to dry. Ask students to identify other common waste products that could potentially be used as energy resources.

2. Discuss how to harness the wind's mechanical energy to generate electricity. Using common woodworking tools, have students shape small strips of wood into wind turbines. Fasten each turbine to a hobby motor mounted on a base and connected to a voltmeter. Position a portable fan a given distance from each model wind generator. Assess the relationship between wind velocity and output energy by moving the fans closer to the wind generators while monitoring the voltage produced by the hobby motors. Ask students to evaluate how variables like wind speed, generator efficiency, blade pitch, and turbine weight and balance affect the wind energy conversion process.

3. Discuss the rediscovery of wind energy due to the high cost and questionable supply of fossil fuel. Using a small bicycle, automotive, or industrial generator, build a wind generator on school grounds. Connect the wind generator to an energy meter and a load (e.g., sign, storage batteries). Monitor the energy produced by the generator for a long period of time. Use the data collected to evaluate the potential and cost-effectiveness of utilizing wind energy in your area. Ask students to identify the advantages, disadvantages, and potential applications of their wind generator.

4. Introduce students to the concept of a wind farm. Have students wire a series of model wind generators together. Using several portable fans, determine the amount of energy produced by the model wind farm. Use the wind farm to illuminate a bulb or power a small motor. Ask students to evaluate the practicality of using wind farm technology to generate electrical energy for your community. Include considerations like land utilization, safety, storage and distribution in your discussion.

5. Discuss how the mechanical energy in moving water can be used to generate electricity. Have students design and build model hydroelectric generators using things like sheet metal, hobby motors, copper tubing, and plastic hose. Connect each hydroelectric turbine/generator to a water distribution manifold connected to a hose bib. Control the pressure produced by adjusting the hose bib valve and using a small orifice to restrict the water striking each turbine. Measure the voltage produced by each turbine/generator. Try illuminating an LED or light bulb with one or more model hydroelectric generator.

6. Introduce students to the concept of geothermal energy. Consider simulating a geothermal deposit by putting water into a sauce pan, covering it with aluminum foil, securing the foil with wire, puncturing the foil with a nail, and placing the assembly on a hot plate. When the water begins to boil, the foil will swell and steam will escape through the hole. Discuss how the hot plate represents super heated rock, the sauce pan and water represent a geothermal deposit, and the aluminum foil represents the earth surrounding a geyser or geothermal well. Ask students how to harness the thermal and mechanical energy produced by the pressurized stream. Explain how geothermal energy is being used to heat living space and generate electricity.

7. Explain how geothermal energy trapped underground can be used to generate electricity. Have students design and build model geothermal power plants using things like sheet metal hobby motors, copper tubing, and plastic hose. Connect each geothermal power plant to a beaker positioned above a heat source. Boil the water and use the steam to drive the turbine driven generator. Use a small orifice to restrict the steam and produce the pressure needed to turn the turbine.

8. Discuss how biomass can be converted to methane gas using anaerobic digestion. Using materials like buckets, glass jugs, aquarium heater, sewage, manure, and algae, have students make and test an anaerobic digester. Include tasks like maintaining temperature, monitoring gas production, and burning the collected gas. Discuss the role of anaerobic digestion as an appropriate technology in third world countries. Ask students to evaluate the role appropriate alternate energy technologies could play in the United States.

9. Explain how biomass materials can be converted to methane gas by means of a pyrolytic converter. Using materials like test tubes, glass tubing, rubber hose, and scraps of wood, have students construct and test a pyrolytic converter. Include tasks like burning wood, collecting gas, igniting the gas, and analyzing the ash. Discuss how the pyrolytic process can be used to convert materials like garbage, wood, and coal into methane gas. Ask students to describe and evaluate the role pyrolytic technology might play as our natural gas deposits dwindle.

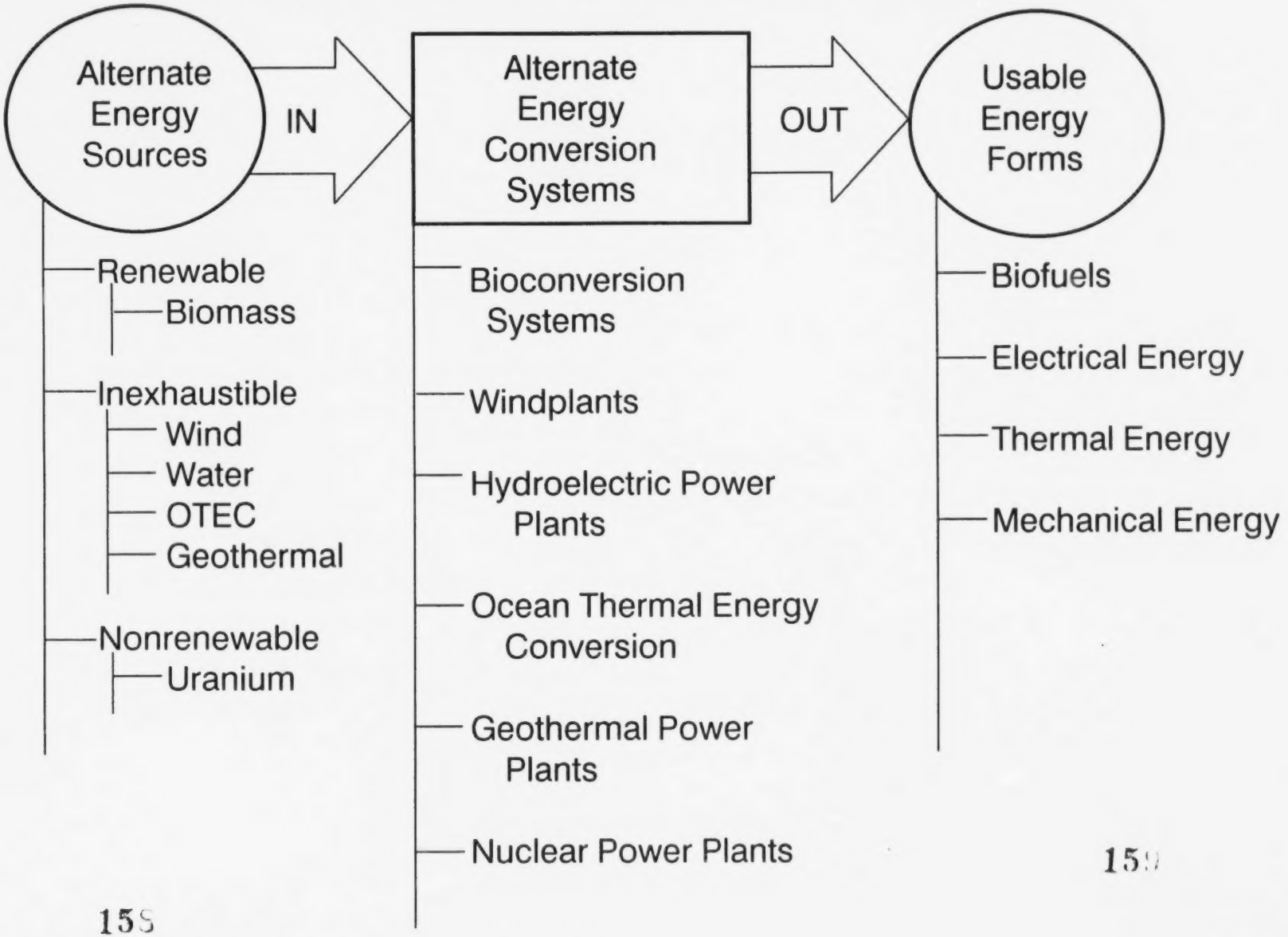
10. Introduce students to the concept of a heat pump. Using large buckets of hot and cold water, a plastic bottle, and a balloon, demonstrate how heat can be moved from one source to another. Have a student fasten the balloon across the mouth of the bottle, place it in the hot water, watch the balloon expand, transfer the bottle/balloon to the cold water, and watch the balloon deflate. Ask students to explain how the thermal energy is being moved and how the energy could be tapped to generate electricity.

11. Discuss how heat from the air, ground, or bodies of water can be extracted and used to heat living spaces and someday, generate electricity. Using components from a discarded refrigerator, have students design, build, and test a heat pump that moves heat from one sealed enclosure to another. Calculate and compare the amount of energy used to power the system and the heat gained in the enclosure. Ask students to identify the potential problems and application for heat pump technology.

12. Discuss the career opportunities in alternate energy systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to alternate energy systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

13. Discuss the milestones in the history of alternate energy systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

USING ALTERNATE ENERGY SOURCES



SOURCES OF ALTERNATE ENERGY

Introduction

Propelling automobiles, manufacturing products, turning on lights, and playing video games all require energy. Today, most of our energy comes from oil, coal, and natural gas. Although these sources have been plentiful in the past, our reserves are beginning to dwindle. As a result, scientists and engineers are beginning to develop new sources of energy.

The earth provides humankind with a variety of sources that can be converted into useful forms of energy. These sources include:

- solar energy
- wind energy
- water power
- bioconversion
- ocean thermal energy conversion
- geothermal energy
- nuclear energy
- coal
- petroleum
- natural gas

Solar energy comes to the earth in the form of light from the sun. Solar energy is the most powerful source of energy on earth. If all the sunlight falling on the earth during three days could be concentrated and converted, it would equal all of the earth's known fossil fuel reserves. Solar energy can be used to heat homes, heat water, and produce electricity. Our challenge is to develop more efficient ways to collect, convert, and store solar energy.

Wind energy is actually a form of solar energy. The sun heats the air around the earth unequally. The differences in air temperature cause the air to move in the form of wind currents. Wind energy can be used to drive propellers called turbines. A wind turbine can be used to turn a generator or a pump. When the wind is not available, electrical energy can be stored in batteries.

Water power is the energy in moving water and it can be used to generate electricity. Waves, tides, river currents, ocean currents, and dams can all be sources of energy. Locations where the energy in moving water can be harnessed are very limited. Today, only 13 percent of the electrical energy needed in the United States comes from hydroelectric power plants.

Bioconversion is the process of converting plants and waste materials into usable forms of energy. By heating materials without oxygen, things like manure, garbage, and sewage can be turned into a gas. Other examples of bioconversion include burning firewood for heat, converting corn into ethanol, and using marine plants to make methane gas. Plant and waste sources must be managed carefully to make sure they are not used up before they can be reproduced.

Ocean Thermal Energy Conversion (OTEC) is a safe and clean source of energy for generating electrical power. In certain tropical locations, surface water warmed by the sun can be used to expand a gas. The expanded gas is used to drive turbines that turn a generator. Cold water can be pumped from the depths of the ocean to condense the gas, and the cycle is repeated.

Geothermal energy is heat trapped inside the earth, as demonstrated by hot springs, volcanoes, and geysers. Hot water or steam is produced when underground water comes in contact with rock heated by the earth's interior. In certain areas this heat can be tapped and used to produce electricity and, in some cases, used to heat homes.

Nuclear energy is the result of splitting a uranium atom and causing other uranium atoms to split in a chain reaction. The energy released during the chain reaction is called fission, and is used to produce steam. The steam drives turbines that turn a generator and produce electricity. A second technique for tapping the energy in an atom is called fusion. Nuclear fusion uses a laser to start the chain reaction and a magnetic field to contain the chain reaction. If the problems can be worked out, nuclear fusion can produce its own fuel. Fear of radiation and the problem of waste have made nuclear energy controversial.

Coal represents 93 percent of the world's and 90 percent of the United State's fossil fuel sources. Coal is called a fossil fuel because it is the product of decayed animals and plants that lived millions of years ago. Dead plants and animals accumulated into a substance called peat. Layers of rock and sediment buried the peat creating pressure and heat. The build up of pressure and heat over millions of years transformed the peat into the rock-like material we call coal. Typically, coal is removed from the earth by means of deep or surface mining, processed, and burned to produce steam in a power plant. However, coal can be converted into a gas or liquid fuel.

Petroleum is a fossil fuel that developed under a dome of rock. Deposits are tapped by drilling a well and refined into useful products like gasoline, diesel fuel, and kerosene. In the United States, more than 50 percent of the petroleum products made are used for transportation purposes in the United States. Petroleum is very appropriate for transportation applications because it has a high energy content, is easy to store and transport. Many experts feel we should save petroleum for applications like transportation where alternative energy sources are not very promising.

Natural gas, like oil and coal, is a fossil fuel, most commonly found with oil deposits. Of all the fossil fuels, natural gas is the easiest to process and transport and burns the hottest and cleanest. About forty percent of the natural gas used in the United States is for the purpose of heating homes and businesses.

WIND ENERGY

The sun heats the earth's surface unequally. The differences in temperature from one place to another as the earth rotates causes the movement of air we call wind. Thus, wind energy is the result of solar energy. Wind energy is free, does not pollute, and is available 24 hours a day. Unfortunately, the amount of wind energy available changes and these changes are difficult to predict.

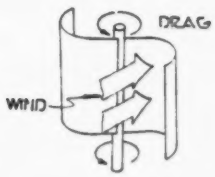
Using the wind as an energy source is an old idea. Windmills for pumping water once was a common sight on American farms. When electrical power became widely available and cheap, most water pumping windmills were taken out of service. There is a renewed interest in the wind as a source of energy due to the rising cost of electricity. The machines that convert the wind's energy into electrical energy are often called windplants. Wind energy could provide 7 to 19 percent of all the electricity used in the United States. Producing more electricity by means of wind energy will help to save fossil fuels. It is important that we conserve fossil fuels for energy problems that only fossil fuels can solve.

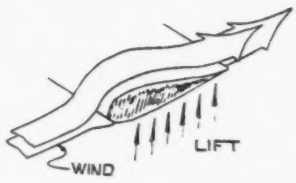
To take advantage of the wind's energy, an area of land is needed that does not have trees, hills or buildings blocking the wind. The site must also have at least an average wind of about 10 miles per hour to be useful. Experts feel a year should be spent studying the wind at a site before the windplant can be built.

Money is a consideration if wind energy is to be used. The wind itself may be free, but the technology needed to convert the energy can be very expensive. A windplant for your home can cost between $5 thousand and $25 thousand. A large scale windplant for a community can cost three to four times what a coal-burning power plant costs.

Today, most windplants are used to generate electricity. To generate electricity the wind flowing across the site must be converted into a rotary motion, using a set of blades called a turbine. The wind causes the turbine to turn, demonstrating the principles of lift and drag.

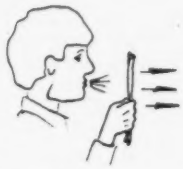
The pushing force of the wind on a flat or cupped surface is called drag. To experience drag, put your hand outside the window of a moving car. Your hand moves backward because of drag. The Savonius windmill, dating back to the 10th Century, used the drag principle to turn the blades (see illustration below). The flow of air around an airfoil-shaped blade produces an aerodynamic action called lift (see illustration below). The movement of air across the top of





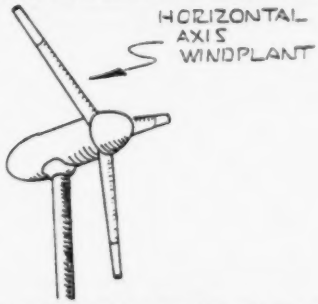
the blade causes a low pressure area. This low pressure area is caused by the air on top of the blade moving much faster than the air under the blade. The higher pressure under the blade causes an upward force. To experience lift, cup a piece of paper in front of your mouth and blow over the top of it (see illustration below). The paper will rise. You can experience drag by blowing air into the center of a piece of paper while holding it in front of our face (see illustration below). The paper moves backwards.

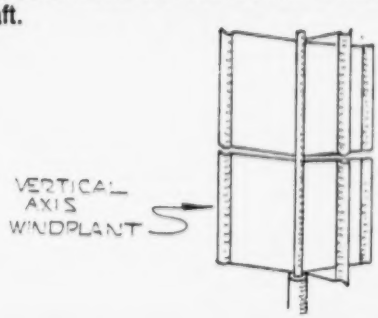
LIFT



DRAG

Two types of windplants are horizontal-axis and vertical-axis (see illustrations below). Horizontal-axis windplants use a turbine that rotates on a horizontal shaft . Vertical axis windplants use a turbine that rotates on a vertical shaft.





Windplants can be designed on a large or small scale. For the most part, engineers and scientists have given most of their attention to large scale windplants. However, many experts now feel small scale windplants have more promise as an alternative energy system.

Large scale windplants use towers between five and ten stories high. The turbines have blades that range between 100 and 300 feet from tip to tip. NASA and the Department of Energy built a windplant in Boone, North Carolina that has a blade diameter of 220 feet. Large scale windplants are more efficient than small scale wind plants. A large scale windplant with a blade diameter of 100 feet can convert four times the energy a windplant with a blade 50 feet in diameter can convert.

There are problems with the large scale windplants however. Large scale windplants may interfere with TV signals, affect the weather, and alter the migratory patterns of birds. For safety reasons, large scale windplants require large amounts of land. Lastly, the electrical energy from large scale windplants can cost up to 10 times what electrical energy costs from fossil fuel or nuclear power plants.

Privately owned small scale windplants are more practical. They are easier to mass produce, less likely to be damaged by the wind, and require less maintenance. Because of their small size, small scale windplants operate a greater percentage of the time. In addition,

small scale windplants can be located closer to the energy user, thus reducing the cost of distribution.

Small scale windplants have some disadvantages too. If small scale windplants become popular, they could create the same visual pollution that oil rigs do in many parts of the country. Lots of independently owned windplants could reduce the role of large power companies. Large power companies may have to increase the price of energy due to reduced demand. In addition, owners of windplants may have to pay higher to power companies rates because they use much less energy.

The amount of wind energy available for conversion varies. On a windy day, there may be more energy available than one can use, and on calm days, there may not be enough energy. There is a need to store excess energy produced on windy days for use on calm days. On windy days and at night, electrical energy is often stored in a series of batteries. On a calm day, the batteries are used to provide electrical energy. The storage batteries will not be able to provide enough energy if you have a lot of calm days in a row. Storage batteries are very expensive. Another solution is to buy energy from the utility company on calm days. On windy days, the utility company is required by law to buy excess energy produced by a windplant.

Materials and Supplies

- 1/4" x 1" x 10" piece of balsa wood
- Fan
- Test fixture (DR #1)

Problem Statement

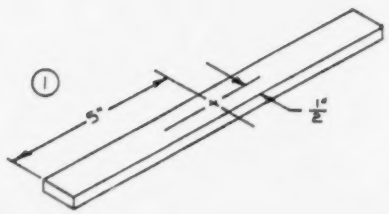
With the cost of fossil fuels increasing, there has been a renewed interest in using the wind to generate electricity. The first part of the wind energy conversion process is to convert the wind's linear mechanical energy to rotary mechanical energy. The second part of the process is to convert the rotary mechanical energy to electrical energy. During the following learning activities, you will apply the concepts of lift and drag to make a wind turbine.

After testing your turbine, you will conduct a wind plant experiment to investigate the relationship between input wind energy and output electrical energy.

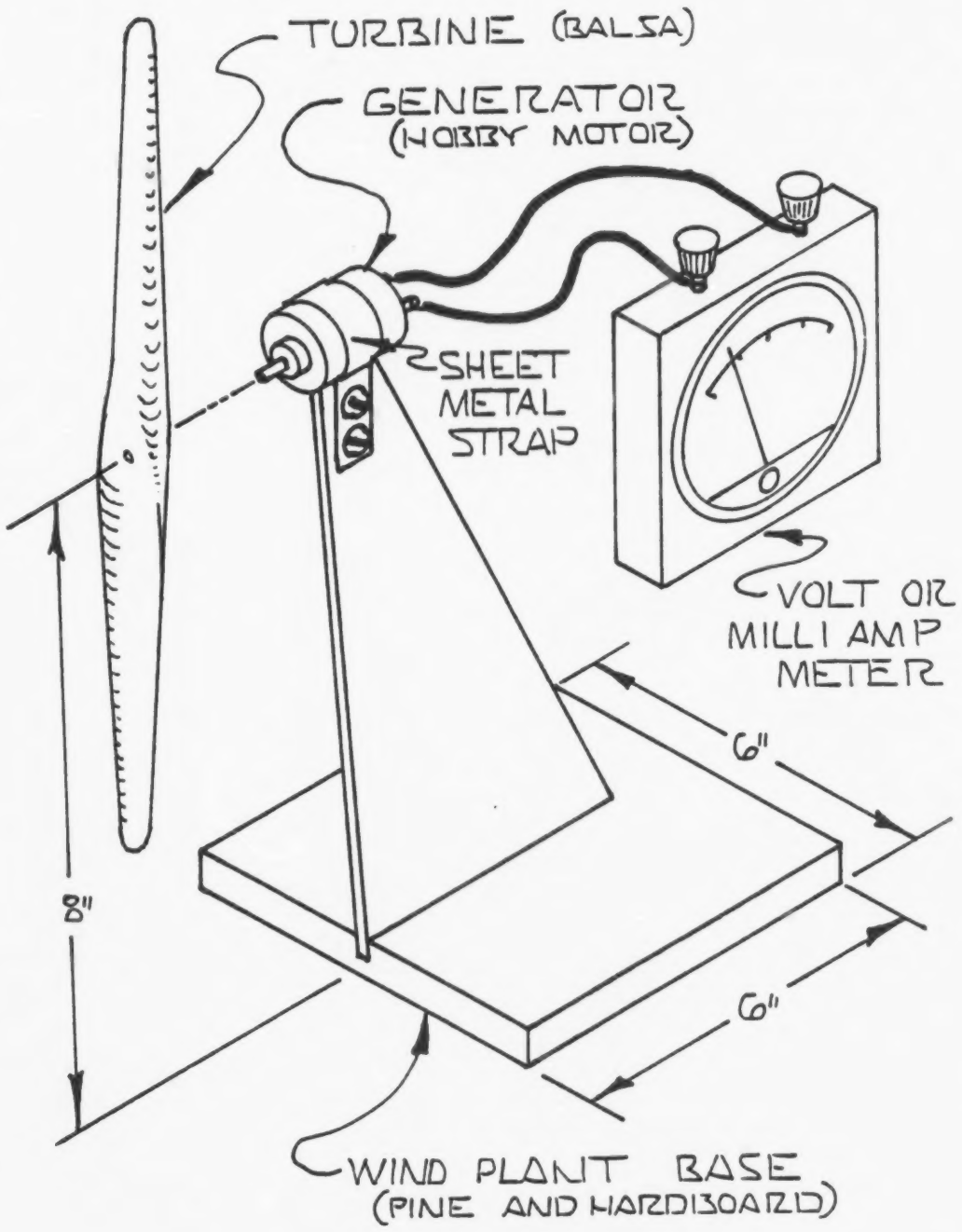
Activity Procedures

Making a Wind Turbine

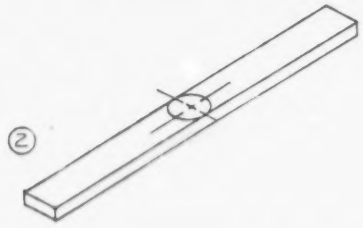
1. Locate and mark the center of your material on one of the half-inch wide surfaces as illustrated.



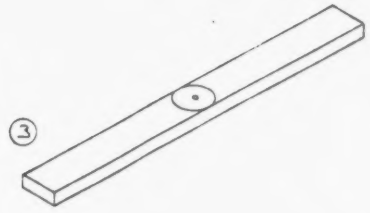
WIND PLANT


TURBINE (BALSA)
GENERATOR (HOBBY MOTOR)
SHEET METAL STRAP
VOLT OR MILLI AMP METER
6"
6"
8"
WIND PLANT BASE (PINE AND HARDBOARD)

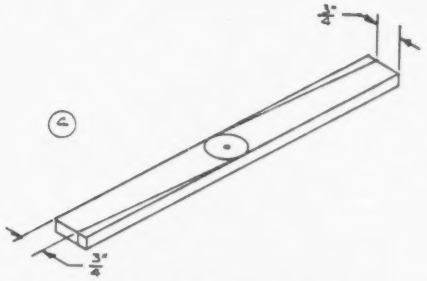
2. Using a compass or circle template, draw a half-inch circle around the center point. Do not sand or file the material inside the half-inch circle.



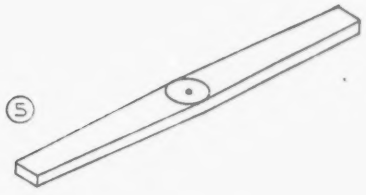
3. Drill a hole through the center of your material smaller than the input shaft on your wind generator. After you finish drilling the hole, you should be able to fasten your material to the generator with a friction fit. Since the hole is very small, you may need to use a small nail for a drill bit.



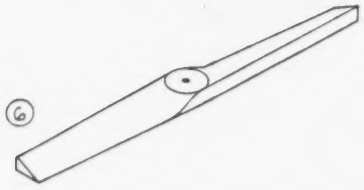
4. Using a straight edge and a pencil, lay out the taper for the blades as illustrated.



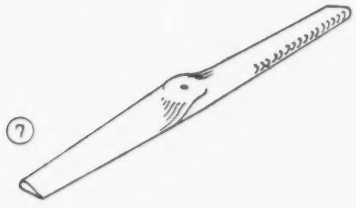
5. File the trailing edges of the material to the taper lines.



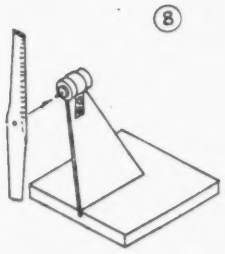
6. Using a file, taper the blades as illustrated. Make sure you taper the blades in opposite directions.



7. Using sand paper, round the leading edges of the blades into an airfoil-like shape.



8. When you have finished your turbine, fasten it to a wind plant, position a household fan about three feet away, and turn it on. Your wind turbine should begin to turn. If it doesn't turn right away, give it a little help. Make additional modifications if needed.



The Problem

How does wind speed affect the energy output from a windplant?

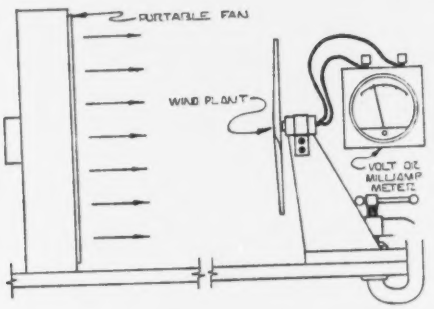
Hypothesis

An increase in wind speed will _____.

A. cause a decrease in energy output
B. cause an increase in energy output
C. not effect the energy output

Experiment Procedure

1. Fasten the wind plant to a table using a C-clamp (see illustration below). Connect a volt or milliamp meter to the wind plant. Using jumper leads, connect the positive terminal on the wind plant to the positive terminal on the meter. Connect the negative terminal on the wind plant to the negative terminal on the meter. Lay out a strip of masking tape from the front of the wind plant to a position about six feet away. Measure one foot along the tape from the wind plant. Call this Test Point 6. Measure along the tape one foot from Test Point 6. Call this new point Test Point 5. Continue counting down test points until you have identified Test Point 1. Position your fan at Test Point 1 and turn it on.



2. Is your turbine turning _____(Yes/no)? If your answer is yes, read the meter and record the current or voltage in the space provided.

_____

3. Move the fan to test point number two. Is your turbine turning _____(Yes/no)? If your answer is yes, read your meter and record the voltage or current in the space provided below.

_____

4. Move the fan to test point number three. Is your turbine turning _____(Yes/no)? If your answer is yes, read your meter and record the voltage or current in the space provided below.

_____

5. Move the fan to test point number four. Is your turbine turning _____(Yes/no)? If your answer is yes, read your meter and record the voltage or current in the space provided below.

_____

6. Move the fan to test point number five. Is your turbine turning _____(Yes/no)? If your answer is yes, read your meter and record the voltage or current in the space provided below.

_____

7. Move the fan to test point number six. Is your turbine turning _____(Yes/no)? If your answer is yes, read your meter and record the voltage or current in the space provided below.

_____

8. Plot your meter readings on the graph below.

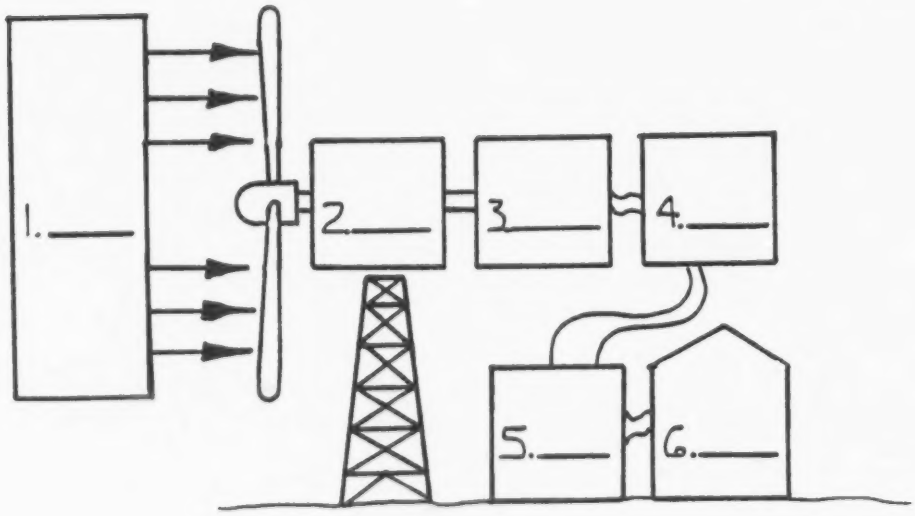
Activity Analysis

1. As wind speed increases, energy output from the wind plant _____.

   A. increases
   B. decreases
   C. stays the same

2. Complete the flow chart by matching the wind energy element (list at the top) with their proper location in the wind energy conversion process.

   A. The generator converts mechanical energy to electrical energy
   B. The consumer utilizes the energy to perform work.
   C. Mechanical energy in the wind is used to turn a turbine.
   D. The mechanical energy from the turbine is used to turn a generator.
   E. Solar energy heats the atmosphere unevenly which produces wind current.
   F. Surplus electrical energy is stored in batteries or purchased by the utility company.

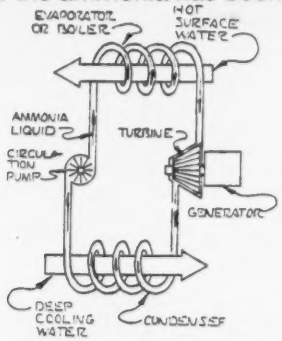


OCEAN THERMAL ENERGY CONVERSION (OTEC)

Introduction

Ocean thermal energy conversion is another form of solar energy. In some parts of the world, the sun heats tropical ocean water on the surface to temperatures of about 80 degrees Fahrenheit. While the surface water is quite warm, water about 1,000 feet down is about 40 degrees Fahrenheit. Ocean Thermal Energy Conversion (OTEC) uses the difference in water temperature to generate electricity. OTEC is still on the drawing boards. An operating OTEC power plant has never been built.

An OTEC power plant is a gigantic floating platform with 50 foot wide pipes projecting down about 1,000 feet below the surface (see illustration below). Warm water from the surface would be used to heat an ammonia liquid. At about 80 degrees Fahrenheit, the ammonia liquid expands into a gas. The expanded gas is under great pressure and is used to drive large turbines. The turbines turn a generator. The generator converts the mechanical energy from the turbines into electrical energy. Cold water from deep in the ocean is pumped up to the platform and used to cool the ammonia gas. When cooled, the ammonia becomes liquid again and the pressure is reduced. After the ammonia has been cooled, the cycle repeats.



There are several problems with the OTEC concepts that still have to be solved. The biggest problem is cost. There are only a few good sites for OTEC in the world. Most of these are miles from shore. The most expensive problem is how to get the electricity produced off shore to the shore where it is needed. In addition, OTEC power plants are subjected to sea water corrosion and damage from ocean storms. Once these problems have been solved, an OTEC plant could be built in 5 to 10 years. Some experts feel energy from an OTEC plant could provide 1 to 5 percent of the United State's energy requirements by the year 2000.

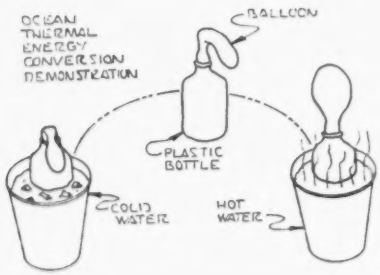
The following Technology Education Activity will introduce students to the basic concept of thermal energy conversion.

Materials and Supplies

- 2 liter plastic soda bottle
- Balloon
- 2 buckets ice
- Hot plate
- Access to water

Activity Procedures

1. In groups of two, obtain the materials listed above from your instructor.
2. Fill one bucket with ice and water.
3. Using the hot plate, bring 3/4 of a gallon of water to a boil.
4. Review the illustration below.



5. Place a balloon onto an empty plastic soda bottle.
6. Place the bottle into the bucket of ice water. Describe what happened.

_____

_____

7. Next, remove the bottle from the ice water and place it into the bucket of hot water. Describe what happens:

_____

_____

8. Repeat the process several times.

Activity Analysis

Based on the experience gained in the activity:

1. Why did the balloon inflate?

_____

_____

2. Why did the balloon deflate?

_____

_____

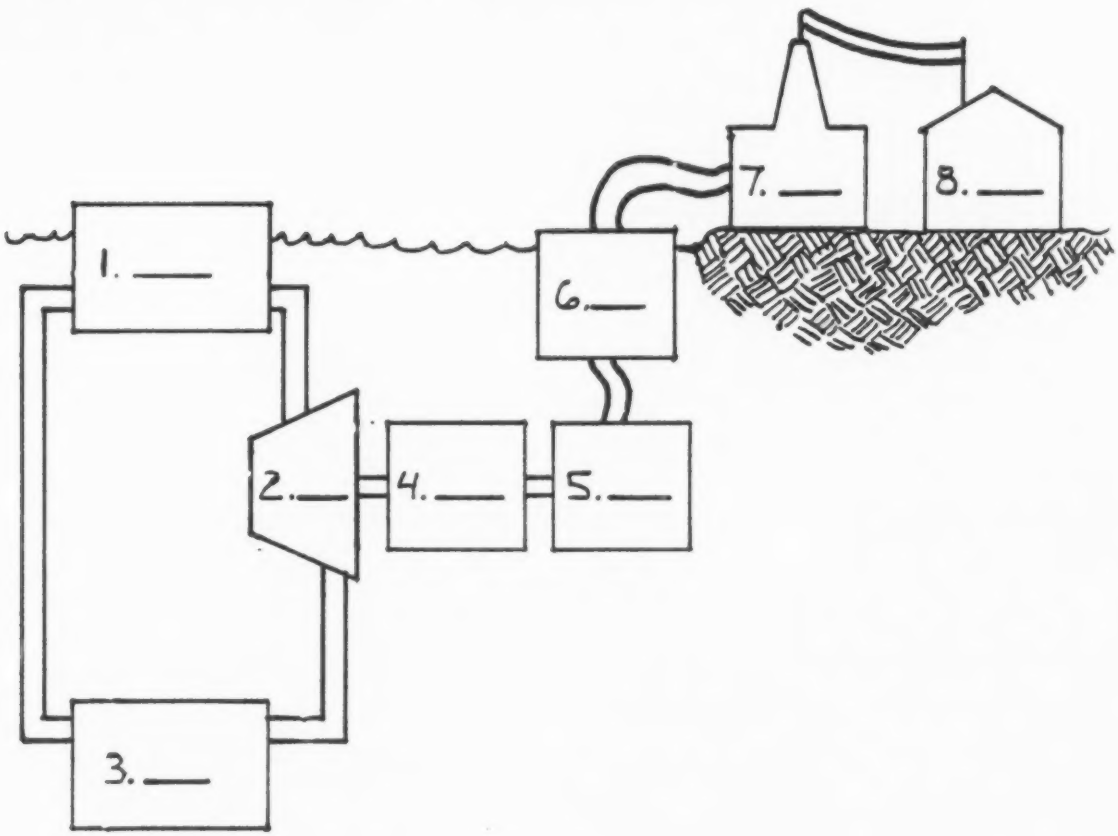
3. If this were an OTEC system, where would you place a generator?

_____

_____

Complete the flow chart below by matching the OTEC elements listed at the top with their proper locations in the OTEC conversion process.

A. Cold water from the ocean bottom is used to condense the ammonia.
B. Electrical energy is brought to the consumer through a distribution grid.
C. Warm surface water expands the ammonia.
D. Mechanical energy from the expanded ammonia is used to turn a turbine.
E. Mechanical energy from the turbine is used to turn a generator.
F. The consumer utilizes the energy.
G. Electrical energy is brought to shore.
H. The generator converts mechanical energy into electrical energy



GEOTHERMAL ENERGY

Introduction

Geothermal energy is basically heat energy from inside the earth. There are two theories why there is heat below the earth's surface. The first theory is the earth is still cooling down from its creation. The second theory is the heat below the earth's surface is caused by the decay of radioactive elements and from magma (a mixture of rock and gases).

Temperatures inside the earth increase as the depth increases. Just below the earth's crust, temperatures between 400 and 1,950 degrees Fahrenheit can be found. Evidence of the heat trapped inside the earth can be seen on the earth's surface. Hot springs, geysers and volcanoes are examples of the heat energy within the earth.

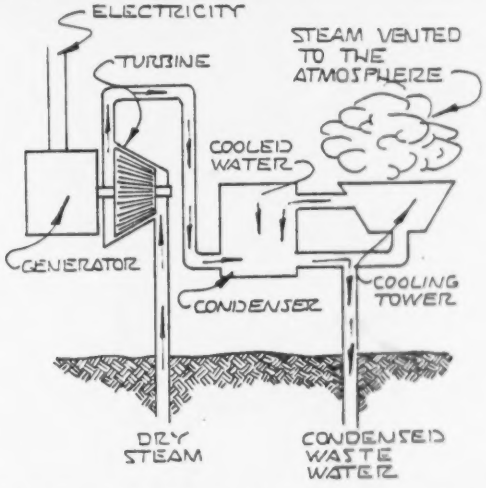
Locating geothermal deposits requires a variety of tools. Geothermal deposits are typically found in areas of recent volcanic activity or mountain building. Locating specific deposits involves studying geologic maps and satellite photos. Studying the ways shock waves and electric waves travel through the earth can also help scientists and engineers locate deposits. Once a deposit has been located, shallow wells are drilled and temperature readings are taken. If the readings are good, deep exploratory wells are drilled to make sure the deposit can be used. Geothermal deposits have been found in the United States (California and Idaho), Italy, New Zealand, Iceland, Japan, Mexico, and the Soviet Union.

Three types of geothermal deposits are dry steam, hot water or wet steam, and dry rock deposits, containing super heated steam with very little moisture. Power plants using dry steam are the most economical to operate. Hot water or wet steam deposits contain super heated water. The super heated water does not boil underground because it is under pressure. When the water is brought to the surface, it becomes steam containing moisture and minerals. Another type of deposit is called a dry rock deposit. In order to take advantage of a dry rock deposit, water is pumped into the well, causing the rock to fracture. Additional water is pumped into the fractured rock, converting it to steam, and then brought back to the surface via a nearby well.

After a deposit has been located, a well is drilled. To tap a geothermal deposit, a well between 30,000 to 50,000 feet deep is required. After the well, a power plant is built, taking about three to five years to build. The steam is cleaned of corrosive contaminants and minerals, and then piped to the power plant.

Steam can be used to drive turbines in one of two ways. In the first, called the flash method, hot water from the well does not boil because it is under high pressure. When the pressure is reduced, some of the water is converted into steam. The steam is used to turn the turbines.

Another method is called the vapor-turbine method (see illustration below). Steam is not used to drive the turbines directly. Instead, the heat from the well water is transferred to a refrigerant material through a heat exchanger, converting the refrigerant material into a gas at a very low temperature. The heat from the hot water causes the refrigerant material to expand and the pressure from the expanded gas is used to drive the turbines. The turbines convert the thermal energy of the steam into mechanical energy. The turbines are used to turn generators. The generators convert the mechanical energy from the turbines into electrical energy. Most of the geothermal power plants are located in remote areas. A long network of power lines are needed to bring the electricity to the populated areas.



Once the geothermal steam is used to drive the power plant turbines, it condenses into water, containing a high concentration of chemicals and sediment. Dumping the waste water into rivers and streams results in a serious pollution problem. Therefore, the waste water is returned to the geothermal deposit in the ground by means of a second well.

Geothermal energy can also be used to heat homes and business. Hot water from the ground cannot be directly piped into people's homes because the minerals would clog the heating system. Therefore, heat exchangers are used to transfer the heat from the geothermal water or steam to purified water from the public utility. The purified hot water is piped to radiators throughout a house or business. The radiators, in turn, heat the living space.

Geothermal power plants produce several forms of pollution. Most geothermal wells vent chemicals causing the air to smell like rotten eggs. Escaping geothermal steam produces an earsplitting hiss. Geothermal power plants also release a lot of waste heat into the atmosphere. The pollution is not thought to be a big problem because geothermal power plants are not located near populated areas. The problems with geothermal energy are not as serious as the problems connected with coal and nuclear energy.

Materials and Supplies

- 3 - 3" x 3" pieces of galvanized pieces of sheet metal
- 1 - 2 1/2" long piece of welding rod
- Scissors

- Drill
- Tin snips
- Razor knife
- Marker
- Pliers
- Soldering iron/gun and solder
- Hobby motor
- 2 - #8 machine screws and nails
- 8 - #6 pan head screws, 1/2" long
- 1 Strip of sheet metal, 1/2" wide, about 8" long
- 1 strip of sheet metal, 1/2" wide and 3 1/2" long
- 1 piece of 1/4" copper tubing about 2" long
- 1 piece of wood, 3/4" thick, 5" wide, and 5" long
- 1 piece of wire insulation, 3/4" long
- Beaker
- Stopper with a hole in it for glass tubing
- Piece of glass tubing
- Length of rubber hose, about 20" long
- Alcohol burner, can of Sterno, or hot plate
- Jumper leads
- Volt meter and/or milliamp meter
- Baking pan
- Steam driven generator
- Beaker stand

Problem Statement

To generate electricity with geothermal energy, thermal energy must be converted to mechanical energy, and the mechanical energy must be converted to electrical energy. During the following learning activities, you will be making and testing a steam driven generator. In addition, you will use your generator to conduct a geothermal energy conversion simulation. Using the knowledge gained during the simulation, you will complete a flow chart illustrating the geothermal energy conversion process.

Making and Testing a Steam Driven Generator

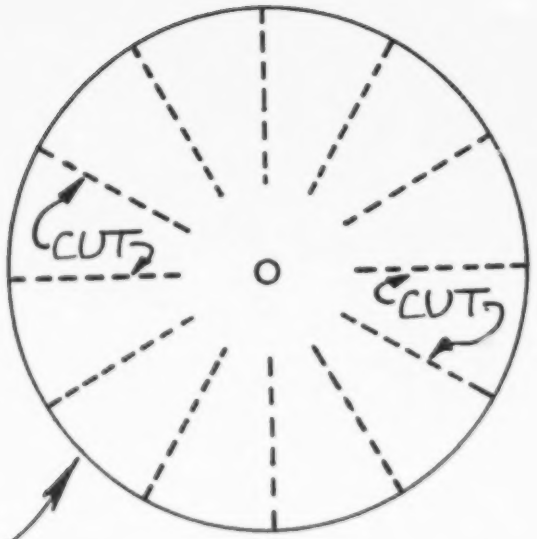
Activity Procedures

During this portion of the lab activity, you will be making a steam driven generator. Your steam generator will have three subsystems: a turbine assembly, a generator assembly, and a steam jet assembly. Assign each member of your team a subassembly. When the subassemblies are complete, assemble, adjust, and test your steam driven generator.

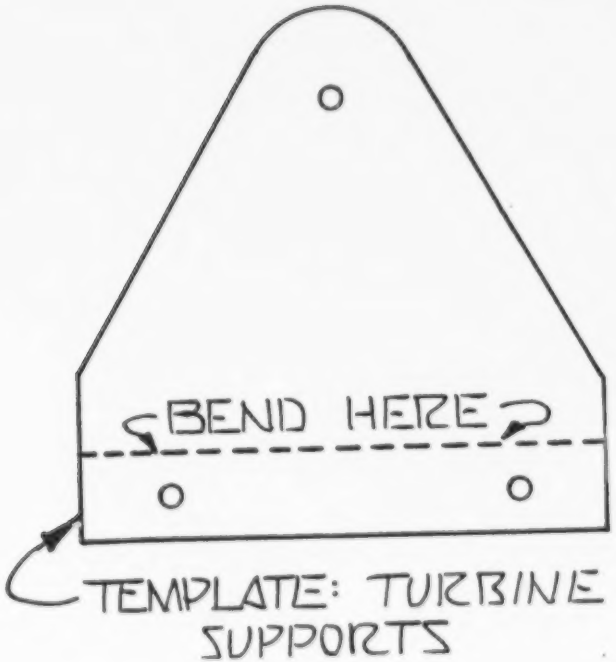
Making the Turbine Assembly:

1. Using the template provided (DR #1), lay out a 3" diameter circle on one of the pieces of galvanized sheet metal. Using a pair of tin snips, cut out the circle.

2. Using a drill bit about the same size as the welding rod, drill a hole through the center of your 3" sheet metal disk.


CUT
CUT
TEMPLATE: TURBINE

23-A


BEND HERE
TEMPLATE: TURBINE
SUPPORTS

DR #1

3. Using the template, lay out the fins for your turbine. Place the template on top of the 3" sheet metal disk. Trace the lines identifying fins with a razor knife. After you have traced all the lines, remove the template. You should have a series of scratches representing the fins on your sheet metal disk.

4. Using a pair of tin snips, cut along the lines scribed into your sheet metal disk. When you have finished, gently twist each blade 90 degrees with a pair of pliers. To keep from distorting the disk, gently twist each blade 10 degrees at a time until you have reached 90 degrees.

5. Insert the welding rod through the turbine about one inch. Make sure the welding rod is perpendicular to the turbine. Solder the welding rod to your turbine using a soldering iron.

6. Using the template, lay out the turbine supports on the two remaining pieces of sheet metal. Cut out the supports using a pair of tin snips. Use the template to locate the holes for the turbine shaft and the mounting screws on each support. Use a drill bit the same size as the welding rod to drill holes for the turbine shaft. Use a drill bit slightly larger than your screws for the mounting holes. Lastly, use a box- and-pan rake or vice to bend each support into shape.

Making the Generator Assembly:

1. Wrap the sheet metal strip around the hobby motor so both ends meet. Pinch the strap so the hobby motor is held firmly. Lay out a hole for a machine screw near the hobby motor. Use a drill bit slightly larger than the machine screw to drill a hole through the metal strap. Insert the machine screw through the hole and fasten both halves of the sheet metal together with a nut.

2. Lay out holes for the mounting screws near the ends of the metal strap. Use a drill bit slightly larger than the mounting screws to drill the holes. Spread the two halves of the metal strap apart. Form the ends of the strap so the generator assembly looks like the one illustrated below.

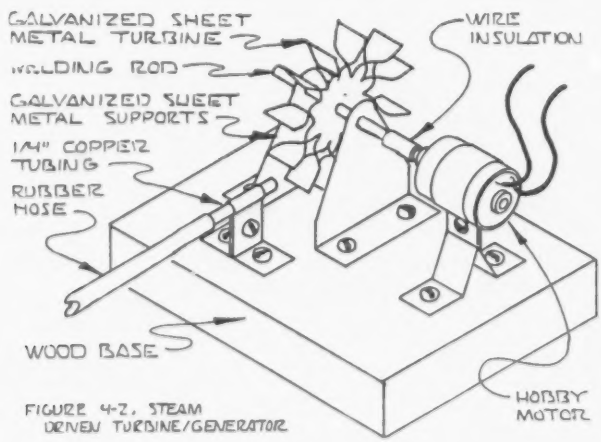


FIGURE 4-2. STEAM DRIVEN TURBINE/GENERATOR

BEST COPY AVAILABLE

Making the Steam Jet:

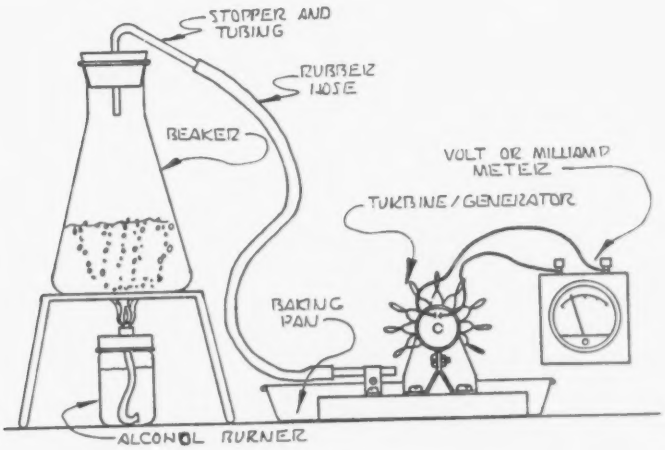
1. Using a soldering iron, fill one end of the copper tubing with solder. After the solder cools, use a tiny drill bit to make a small hole in the middle of the solder.

2. Wrap the sheet metal strip around the copper tubing so both ends meet. Pinch the sheet metal strip so the copper tubing is held firmly. Locate a hole just beneath the copper tubing for a machine screw. Use a drill bit slightly larger than the machine screw to drill a hole through both halves of the sheet metal strap. Fasten both halves of the sheet metal strap together with a machine screw and nut.

3. Locate holes for the mounting screws near the ends of the sheet metal strap. Use a drill bit slightly larger than the mounting screws to drill the holes. Form the ends of the strap so the steam jet assembly looks like the one illustrated in the plan.

Assembling and Testing your Steam Driven Generator:

1. Using a piece of wire insulation, connect the turbine shaft to the shaft on the hobby motor. Position the turbine assembly, generator assembly, and steam jet assembly on the piece of wood as illustrated in the plan. Locate and mark the holes for the mounting screws. After the holes have been marked, remove the assemblies. Using a drill bit slightly smaller than the mounting screws, drill a hole 1/2" deep at each mounting screw location. After the holes have been drilled, relocate each subassembly and install their mounting screws (see illustration below).



2. When the steam driven turbine has been assembled, it needs to be tested and adjusted. Try blowing a steam of air across the top of the turbine. The turbine should turn freely, rotate the turbine shaft by hand and look for unwanted friction or tension in the system. For example, the turbine shaft and the hobby motor shaft might not be properly aligned. If not, adjust the metal strap holding the generator. Experiment with your generator until the turbine turns freely.

Conducting Geothermal Energy Conversion Simulation:

Note: During this portion of the lab activity, you will be conducting a geothermal energy conversion simulation. Work as a team when setting and conducting the simulation. Observe all safety rules and wear eye protection during the simulation.

1. Put the steam driven turbine inside the baking pan. Place the beaker on its stand and position the heat source under the beaker. Pour about six ounces of water into the beaker. Install a piece of glass tubing in the rubber stopper. Cap the beaker with the rubber stopper. Connect the glass tubing coming from the beaker to the steam driven turbine with the rubber hose.

2. Using the jumper leads, connect the generator to a volt meter or milliamp meter. Connect the positive terminal of the generator to the positive terminal of the meter. Connect the negative terminal of the generator to the negative terminal of the meter. Turn the turbine shaft in the same direction it will be turned when driven by steam. The needle on the meter should move into the dial. If it does not move, switch the wires on the meter. Try rotating the turbine shaft again. If the needle still does not move, ask the instructor for assistance.

3. When the simulation is set up and the instructor has approved it, light the alcohol burner, can of Sterno, or hot plate. After the water begins to boil, steam will be produced. When the water is under full boil, the pressure produced by the steam jet will rotate the turbine and generator. When the turbine reaches full speed, read the meter, and record the voltage or current in the space below.

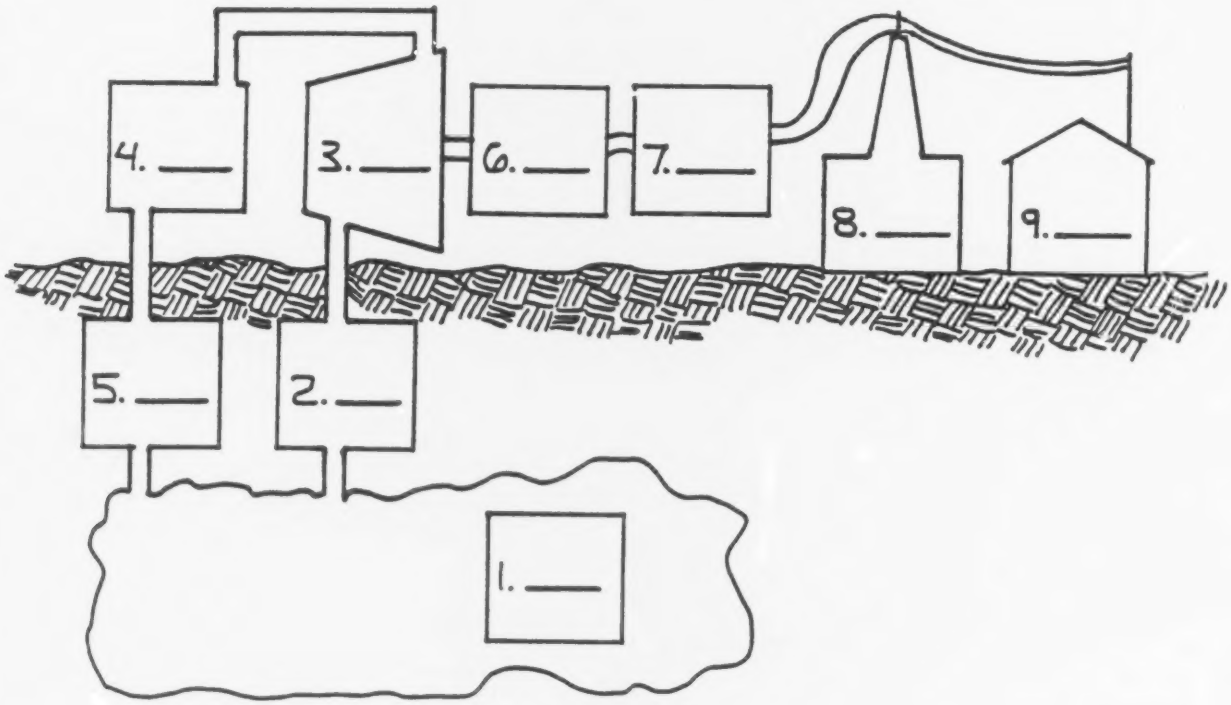
   _____

4. After your have taken your meter reading, extinguish the alcohol burner or can of stern. Once the components have cooled, disassemble your geothermal simulation and clean up your work station according to your teacher's instructions.

Activity Analysis

1. Complete the flow chart by matching the geothermal elements (listed at the top) with their proper location in the geothermal conversion process.

   A. Used steam is condensed in a cooling tower.
   B. The electrical energy is brought to the consumer by means of a distribution grid.
   C. Mechanical energy from the turbine is used to turn a generator.
   D. Super heated steam is brought to the surface by means of a well.
   E. The consumer utilizes the energy to perform work.
   F. The generator converts mechanical energy to electrical energy.
   G. The super heated steam is used to turn a turbine.
   H. Super heated steam is trapped underground in a geothermal deposit.
   I. Contaminated water is returned to the geothermal deposit by means of a second well.



2. List three examples of natural geothermal power.

A. _____

B. _____

C. _____

3. List and describe three basic types of geothermal wells.

A. _____ _____

B. _____ _____

C. _____ _____

BIOMASS ENERGY

Introduction

Plants represent an indirect form of solar energy. About 0.1 percent of the solar energy striking the earth is stored in its plant life. Plants provide a useful form of energy called biomass. Plants that provide biomass are trees, sugar cane, cassava, sorghum, and corn. Examples of aquatic plants that provide biomass include algae, kelp, and water hyacinth. In addition to plants, animal waste, municipal sewage, and garbage also provide biomass masterial. In every case, biomass materials once grew in sunlight and store solar energy through a process called photosynthesis.

One of the most direct ways of converting biomass materials into energy is called metabolic conversion. Metabolic conversion means eating and digesting biomass materials. When we eat and digest food from plants, our bodies convert the biomass into the energy we need to live. Another direct way of converting biomass into energy is by direct combustion (burning it). Burning wood is the most commonly used form of biomass energy other than food. Many third world countries rely on wood as their main energy resource.

Biomass materials can be converted into more useful forms of energy called biofuels. Converting biomass into biofuels is called bioconversion. Many experts hope biofuels will reduce our need for petroleum in the future. Examples of biofuels include methane gas, alcohol, and petroleum.

One advantage biomass has over many other forms of energy is it is a renewable energy resource. Renewable energy resources must be managed properly. For example, the process of cutting down trees for firewood must also include planting trees for the future. If too many trees are cut down without planting new trees, someday we will not have trees large enough for firewood, lumber or paper. A careful balance between harvesting and planting must be maintained. Another advantage to biomass energy is that it can turn what would otherwise be waste into usable energy.

Biomass energy requires a lot of land. If the state of Arizona was planted with a high energy crop, it could only provide one-tenth of the energy now being provided by fossil fuels in the United States. In addition to land, biomass energy requires a lot of energy. Energy is needed to plant, grow, harvest, transport, process and convert a high energy crop. Sometimes, more energy is needed to develop an energy crop than the energy crop has to offer.

Many forms of biomass energy are now being used in the United States. About one-fifth of the homes in the New England area are being heated with wood, and over half of the homes in New England use wood as a supplementary means of heating.

In many areas of the United States, gasohol is being used to power automobiles. Gasohol is 10 percent alcohol and 90 percent gasoline. The alcohol comes from an energy crop like corn, cassava, or sorghum. Gasohol can play a very big role in conserving petroleum energy resources.

Waste disposal is a big problem in many cities. Large cities have solved the problem by burning solid trash and using the heat to drive turbines and generate electricity. The city of Los Angeles has tapped its landfills to heat homes. Landfills are basically large pits in the ground. Garbage is dumped into the pits. When full, the garbage is buried by filling the pit with the dirt. Since the garbage is decaying underground without air, a biogas is produced. The biogas is burned and the heat is used to heat homes.

Problem Statement

Combustible materials can be processed into solid fuel using a process called densifying biomass fuel or DBF. During this process, combustible materials are shredded, compressed, and dried. During this learning activity, you will process waste paper into a solid fuel that can be burned in a barbecue grill, fireplace, or wood stove.

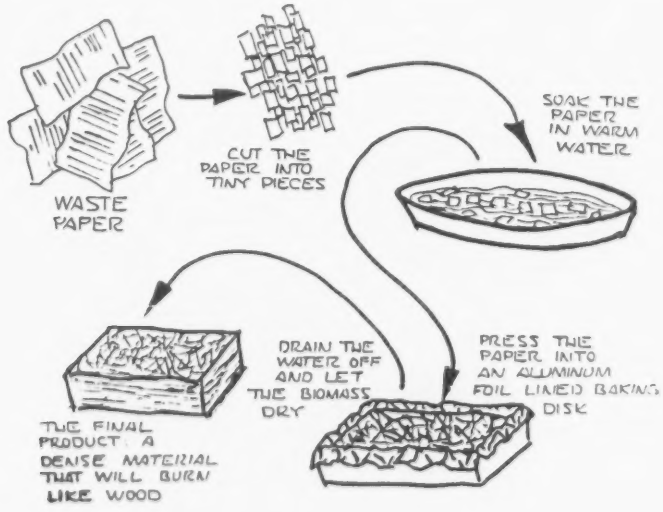
Materials and Supplies

Each group of two students will need the following:

- Waste paper
- Pan, approximately 12"
- Access to warm water
- Aluminum foil
- Plastic food container, approximately 2" x 10" x 14"
- Scissors

Activity Procedures

1. Study the drawing below.

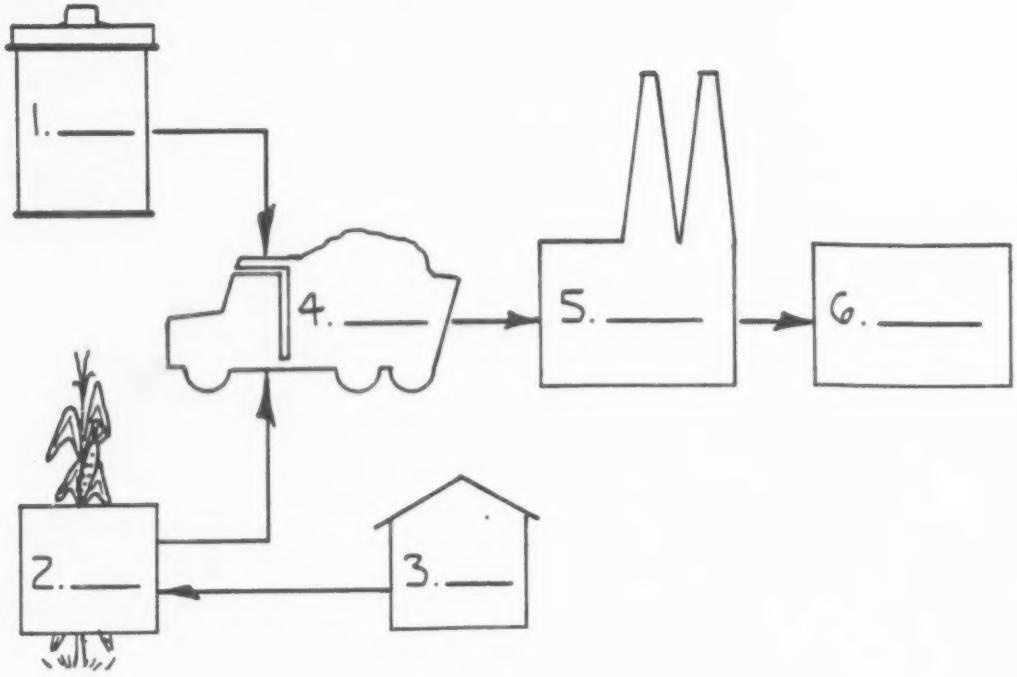

WASTE PAPER
CUT THE PAPER INTO TINY PIECES
SOAK THE PAPER IN WARM WATER
PRESS THE PAPER INTO AN ALUMINUM FOIL LINED BAKING DISK
DRAIN THE WATER OFF AND LET THE BIOMASS DRY
THE FINAL PRODUCT: A DENSE MATERIAL THAT WILL BURN LIKE WOOD

2. Obtain waste paper from the instructor.
3. Cut the paper in to pieces no bigger than 2 inches.
4. Place the pieces of paper in to a pan of warm water.
5. While the first batch of paper is soaking, line the plastic food container with aluminum foil.
6. Place the water soaked pieces of paper in the container so each layer will overlap. With every layer, use a piece of scrap paper to press and blot up the excess water from the waste paper.
7. Continue this process until the paper layer is about one inch thick.
8. Press the mass one last time and drain off as much water as possible.
9. Allow the waste paper mass to dry in its aluminum liner.
10. Because of greater density, the finished fireplace log should burn slower than unprocessed waste paper.

Activity Analysis

After you have finished the biomass log, complete the flow chart below. Match the biomass elements listed at the top with their proper location in the biomass conversion process.

A. Transport the biomass materials for processing
B. Utilize biofuels to heat living space, power automobiles, and/or generate electricity.
C. Collect waste materials.
D. Process the biomass materials into usable biofuels.
E. Manage the production and harvesting of organic materials.
F. Produce and harvest organic materials.



2. Identify three basic processes for converting biomass.

_____

_____

_____

3. Identify two advantages of biomass.

_____

_____

4. Identify two disadvantages of biomass.

_____

_____

_____

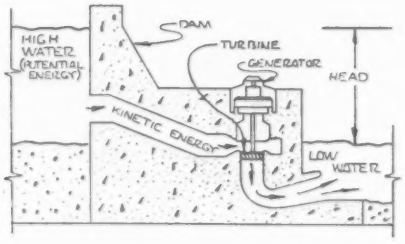
WATER POWER

Introduction

Moving water contains mechanical energy that can often be converted into electrical energy. Examples of moving water that can be harnessed include waves, tides, river currents, ocean currents, and water released from a dam.

Hydroelectric Energy:

The energy in water flowing down a hill varies because of changes in water flow. The flow of water can be controlled with a dam. Water power plants that use dams are called hydroelectric power plants. The dam stores water that can be released in a consistent manner. Released water is used to turn turbines. The turbines convert the linear mechanical energy in the moving water into rotary mechanical energy. The rotating turbines are used to drive generators. The generators convert the mechanical energy from the turbines into electrical energy.



Sites for large scale hydroelectric power plants are very limited. A site must have a high rate of water flow, the ability to store a lot of water, and be able to create a large head (the distance between the top of the stored water and the bottom of the dam where the water will be released). In order to be useful, the hydroelectric plant must be near population centers, and in areas that experience heavy rainfall.

Most of the plans to build new hydroelectric power plants in the United States have been stopped. People are concerned about the effects hydroelectric power plants have on scenic rivers and the surrounding wildlife. For example, salmon need to swim upstream every year to spawn. Fish ladders have to be built to enable the salmon to swim over the dam. Unfortunately, the number of salmon able to make the trip upstream has been reduced despite the fish ladders. Once a dam is built, farmland, forest, wildlife habitats, and even communities are flooded. Most of the dams in the United States over 25 feet tall are not being used to generate electricity.

Hydroelectric power is very efficient. Eighty-five to ninety percent of the energy in the moving water can be converted into electricity, the cheapest kind of electrical energy available. Best of all, hydroelectric power plants do not pollute water or air.

Energy from Tides:

Tides are another form of moving water that can be used to generate electricity. Tides are caused by the gravitational force between the earth and the moon. The moon pulls the oceans away from the earth causing a bulge. As the earth rotates, the pulling action causes the bulge to move, and this produces tides. The energy in the tides can be harnessed by building a dam across a bay or estuary. When the tide is high, the dam is closed and the tide water is trapped. When the tide goes out, there is a difference in water level between the water behind the dam and the low tide water. When the water behind the dam is released, it is used to turn turbines. The turbines are linked to generators that convert the water's mechanical energy into electrical energy.

There are about 24 places in the world where tidal power can be harnessed. The site must experience a five foot change in water level for it to be worthwhile for a tidal power plant. The United States has only two good sites for tidal energy, Cook Inlet in Alaska and Passamaquaddy Bay in Maine.

Wave Energy:

Waves are caused by the wind, and solar energy creates the wind. Therefore, waves are another form of solar energy. The energy in waves is very difficult to harness. Great Britain and Japan seem to be the only two countries that feel the wave energy available to them is worth serious research. Scientists are still experimenting with ways to harness the energy in waves. It will be some time before wave energy is a developed technology.

Ocean Current Energy:

Another idea still on the drawing board is that of harnessing ocean currents. Engineers hope to someday anchor giant turbines under water in the path of the Gulf Stream along the Florida coast. The ocean currents pass through the turbines as the wind passes through a wind turbine. The ocean current causes the turbines to turn and generators to produce electricity. The energy available in the Gulf Stream is estimated to have fifty times more energy than all the rivers in the world put together.

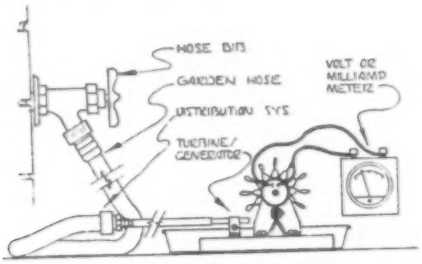
Moving water contains mechanical energy that can be used to generate electricity. Examples of moving water include rivers, streams, water released from dams, ocean currents, tides, and waves. During the energy conversion process, moving water is used to drive turbines. The rotating turbines are used to drive generators that convert mechanical energy into electrical energy. Examples of water power technology include hydroelectric power, tidal power, wave power, and ocean current energy. Water power is efficient, nonpolluting, and inexpensive. However, the number of sites where water power can be tapped are very limited.

Materials and Supplies

- One turbine/generator assembly (see Geothermal Energy activity)
- One volt meter and/or milliamp meter
- Two jumper leads
- One length of rubber hose, about 20' long
- Access to a water source
- Garden hose
- Reduction fittings for end of the garden hose.

Problem Statement

To generate electricity with water power, the mechanical energy in the moving water must be converted to electrical energy. During the following learning activities, you will be conducting a water power energy conversion simulation (see illustration below). In addition, you will use the knowledge gained during the simulation to complete a flow chart illustrating the water power energy conversion process.



1. If you are conducting the simulation indoors, place the turbine/generator in a baking pan. During the simulation, make every effort to keep water inside the pan.

2. Use the jumper leads to connect the generator to a volt meter or milliamp meter. Connect the positive terminal of the generator to the positive terminal of the meter. Connect the negative terminal of the generator to the negative terminal of the meter. Turn the turbine shaft in the same direction it will be turned in the simulation. The needle on the meter should move. If it does not move, switch the wires on the meter. Try rotating the turbine shaft again. If the needle still does not move, ask your instructor for assistance.

3. Connect the turbine/generator assembly to a water source using the rubber hose. Make sure the hose does not slide off its fittings when the water pressure is applied to the system.

4. When the simulation is set up and your instructor has approved it, open the tap slowly and apply water pressure to the turbine. When the turbine begins to rotate, read the meter, and record the voltage or current in the space below.

   _____

5. Increase the pressure being applied to the turbine. Read the meter and record the voltage or current in the space below.

   _____

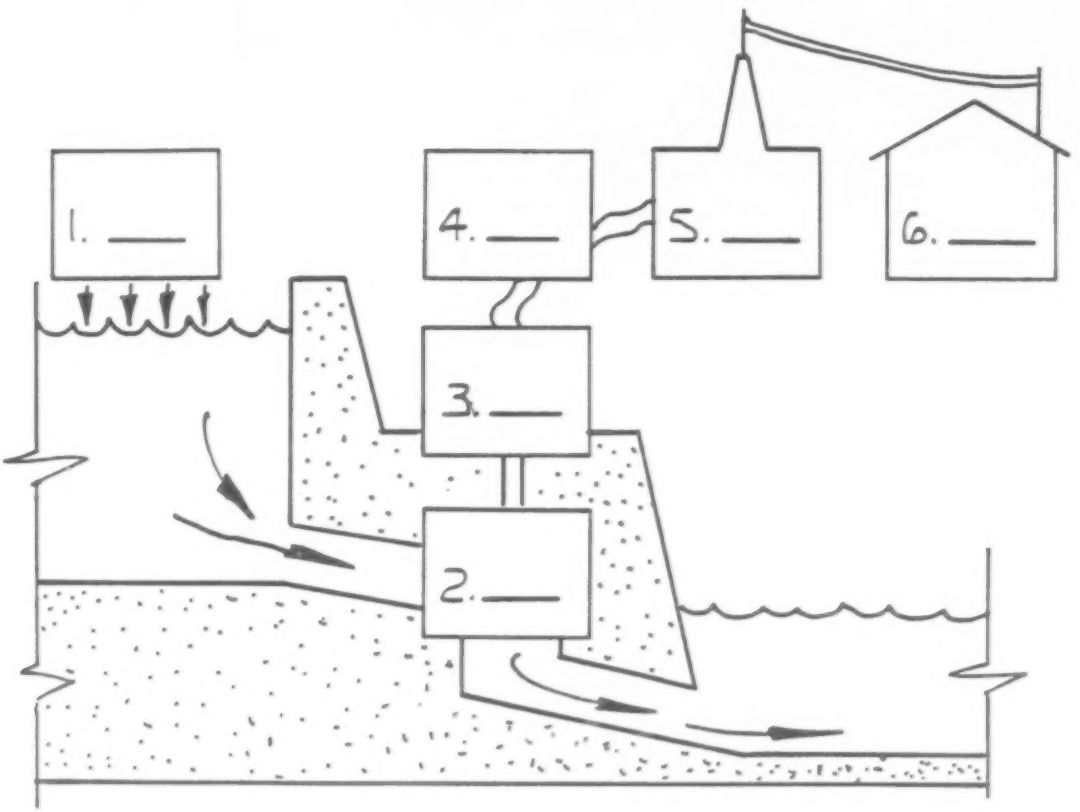
6. As water pressure increases, energy output from the turbine/generator _____.

   A. increases
   B. decreases
   C. stays the same.

Activity Analysis

1. Complete the flow chart illustrated below by matching the water power elements (listed at the top) with their proper location in the water power energy conversion process.

A. The rotating turbine is used to drive a generator
B. A force is applied to a body of water to cause it to move.
C. The electrical energy is distributed to the customer through a distribution grid.
D. Utility customers use electrical energy to perform work.
E. The mechanical energy in the moving water is used to drive turbines.
F. Generators convert the mechanical energy to electrical energy.



2. List and describe four basic type of water power technologies.

A. _____

B. _____

C. _____

D. _____

3. Explain how mechanical energy is converted into electrical energy in a hydroelectric power plant.

_____

_____

_____

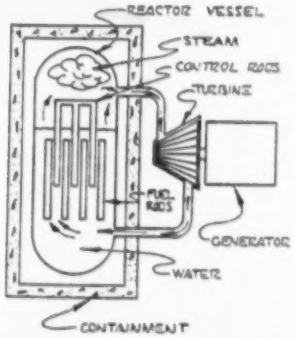
NUCLEAR ENERGY

Introduction

Nuclear energy is released when an atom of matter is split. Matter is basically any material. The matter used most for nuclear energy is called uranium 235. In terms of energy, one ton of uranium 235 is equal to 320,000 tons of coal.

Uranium is a material that is found in the earth, removed by means of underground or surface mining techniques. Only a fraction of the uranium mined can be used in a nuclear power plant. Once mined, it must be refined before it can be used in a power plant. Just like fossil fuels, someday we will deplete our source.

Splitting a uranium atom causes other uranium atoms to split in a chain reaction. This chain reaction must be carefully controlled and contained. The energy released is called fission, creating a lot of heat. The heat is used to produce steam, the steam is used to drive turbines, and the turbines turn a generator, converting mechanical energy into electrical energy.



Containing the chain reaction is very important. Without containment, the heat and radiation produced during the chain reaction escapes. For safety purposes, the inner walls of a nuclear reactor are often made out of steel between 9 and 12 inches thick. The outer walls are made of reinforced concrete several yards thick.

Once a chain reaction starts, the operators of a nuclear power plant must be able to control it. In an emergency, the operators must be able to stop the chain reaction. When a uranium atom is split, it releases neutrons. Before the atom was split, the neutrons were part of the atom's center. The released neutrons travel at a speed of about 7000 feet per second. Part of the controlling process is to slow these neutrons down, which is done by using water or graphite in the reactor.

Another part of the controlling process is being able to absorb neutrons released during the chain reaction. A nuclear reactor contains control rods, made of a material that absorbs neutrons. Putting a part of the control rods into the chain reaction enables the operators to control the chain reaction. Putting all of the control rods into the chain reaction causes the chain reaction to stop.

The most common use for nuclear energy is generating electricity in a power plant. However, nuclear energy can also be used to power large ships. Aircraft carriers, submarines, and some commercial ships are powered by nuclear energy.

After nuclear fuel has been used, it must be handled carefully because it is radioactive. The used fuel must first be stored in water for several months. During this temporary storage, its radioactivity has been reduced by more than 90 percent. After the radioactivity has been reduced, the used fuel can be shipped to a new storage site. Used fuel still contains useful by-products that can be made into new fuel. After the useful by-products have been removed, nuclear waste is left over. The waste must be stored in a location where it will be safe for millions of years. One method of storing nuclear waste is burying it underground in salt formations. Another method being proposed is to bury it in the ocean floor. Only a fraction of the nuclear waste produced comes from nuclear power plants; most waste is the result of making nuclear weapons.

Nuclear energy has several advantages. Once a nuclear power plant has been built, operating the plant is very inexpensive. Because nothing is being burned, nuclear power plants do not pollute the air. Mining uranium causes less damage to the environment than mining coal. The United States has a good supply of uranium.

Nuclear energy has several disadvantages. Nuclear power plants use water from rivers or lakes to cool the reactor. The water leaving a nuclear power plant is very hot. Dumping hot water into a river or lake can damage its animal and plant life. Nuclear power plants have become very expensive to build. Because of the high cost, most plans to build new power plants have been canceled. Lastly, nuclear waste is a big problem for the United States. Many states have created laws to prevent the storage of nuclear waste in their state.

Materials and Supplies

- Two small hobby motors
- One six volt battery
- One milliamp meter
- One volt meter
- One small light bulb or LED
- Five test leads with alligator clips
- Precut pieces of wood for the power plant platform
- One piece of wire insulation about 1/2" long
- Two nylon wire ties

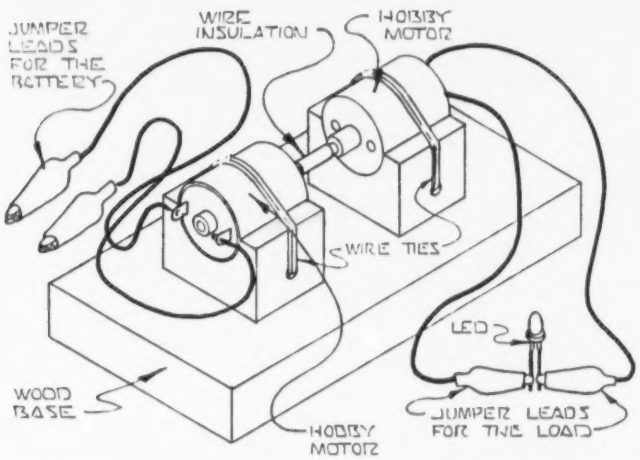
Problem Statement

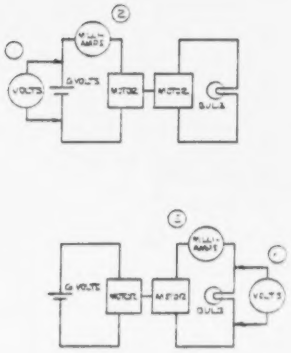
To generate electricity with nuclear energy, the energy released when a uranium atom is split needs to be converted into mechanical energy, and the mechanical energy must be converted to electrical energy. During the following learning activities, you will be making and testing a simple nuclear power plant simulator. In addition, you will determine your simulator's efficiency, and complete a flowchart illustrating the nuclear energy process.

Activity Procedures

Making and Testing a Nuclear Power Plant Simulator

1. Study the illustration and schematic below.





2. Use wire insulation to link the two hobby motors together as illustrated. Assemble the wooden base for your nuclear power plant simulator according to the teacher's instructions. When it is finished, position the two hobby motors on the base. Fasten the motors in place with nylon wire ties.

3. Use jumper leads to connect a light bulb or LED to one of the motors. Using a second set of jumper leads, connect the other motor to the six volt battery. To turn your simulator on and off, simply remove one of the jumper leads on the battery. When all the connections have been made, your simulator should be running and the light bulb or LED should be lit. If you are using a LED as a light source and it is not lit, try switching the jumper leads. If your LED still does not light, ask your instructor for assistance.

Conducting a Nuclear Power Plant Simulation:

1. With the simulator running, measure the voltage across the battery using a volt meter. Touch the positive test lead to the positive terminal of the battery. Touch the negative test lead to the negative terminal on the battery. Read the meter and record the voltage in the space below.

_____ volts

2. Measure the current flowing between the battery and the first hobby motor with a milliamp meter. Connect the positive test lead to the positive terminal on the battery. Connect the negative test lead to the jumper wire coming from the hobby motor. Read the meter and record the current in the space below.

_____ milliamps

3. Using the formula below, calculate the amount of power being used by the first motor.

   Power = voltage x current

   Power = _____ x _____

   Power = _____

4. Measure the voltage across the light bulb with a volt meter. Touch the positive test lead to the positive terminal on the light bulb. Touch the negative test lead to the negative terminal on the light bulb. With the simulator running, read the meter and record the voltage in the space below.

   _____ volts

5. Measure the current between the motor and the light bulb with a milliamp meter. Connect the positive test lead to the positive terminal of the motor. Connect the negative test lead to the jumper wire going to the light bulb. With the simulator running, read the meter and record the current in the space below

   _____ milliamps

6. Using the formula below, calculate the power being used by the light bulb.

   Power = voltage x current

   Power = _____ x _____

   Power = _____

7. Calculate the simulator's efficiency using the formula listed below.

   Efficiency = output power/input power x 100
   Efficiency = _____/_____ x 100

   Efficiency = _____

8. The amount of input energy needed to generate electricity is _____ the amount of energy produced.

   A. greater than
   B. less than
   C. equal to

Activity Analysis

1. Complete the flowchart illustrated below by matching the nuclear energy elements (listed at the top) with their proper location in the nuclear energy conversion process.

A. The energy released during the chain reaction is used to produce steam.

B. The generator converts the mechanical energy into electrical energy.

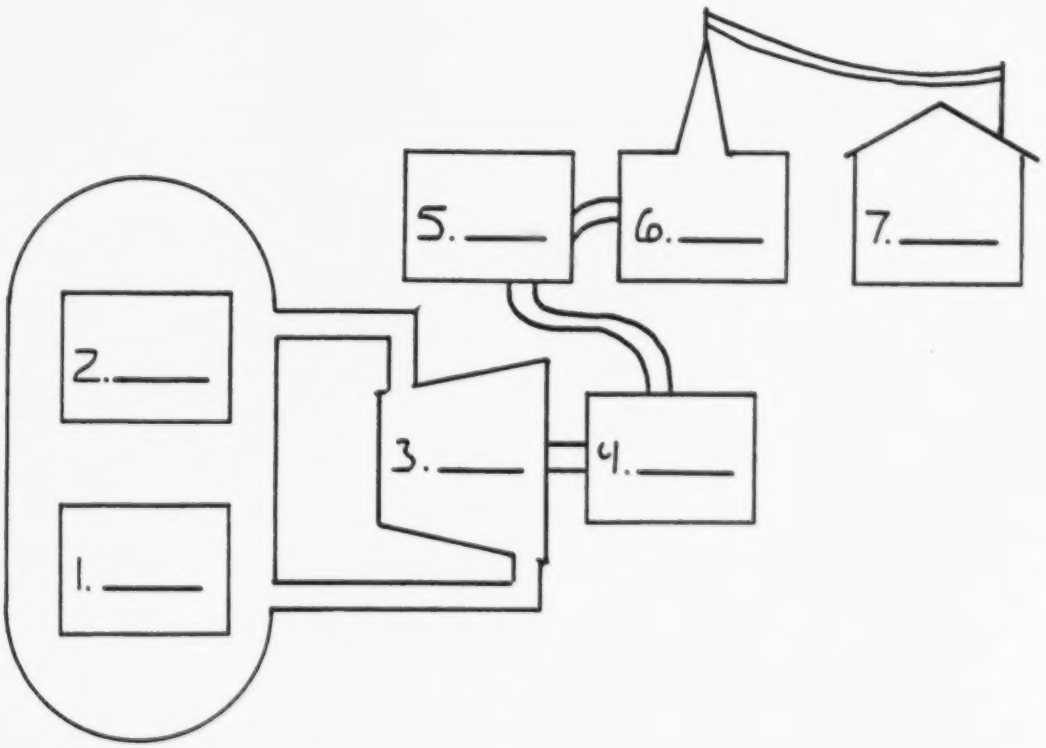
C. Energy is released when uranium atoms are split during a chain reaction.

D. The rotating turbine is used to drive a generator.

E. The mechanical energy produced by the steam is used to turn a turbine.

F. The utility company's customers use the electricity to perform work.

G. The electrical energy is distributed to the utility company's customers through a distribution grid.



2. List the correct sequence for the four steps in the nuclear fuel cycle.

_____

_____

_____

_____

3. List two advantages of nuclear power.

_____

_____

4. List two disadvantages of nuclear power.

_____

_____

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